CONTRACT NO. A132-103
FINAL REPORT
OCTOBER 1994

Land Use and Travel Behavior: PART I

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD
Research Division

LAND USE AND TRAVEL BEHAVIOR

Part I

Final Report

Contract No. A132-103

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October 1994

Acknowledgements

The authors wish to express their thanks to Anne Geraghty, Fereidun Feizollahi and Terry Parker of the California Air Resources Board for the continuous support they provided throughout the project, and Chuck Purvis of the Metropolitan Transportation Commission who provided the San Francisco Bay Area demographic and land use data base for this study. Stephen Potter of the Open University, London, and John Robinson of the University of Maryland assisted in the development of the survey instruments used in the study. We also wish to thank the many graduate and undergraduate students who contributed in various phases of the project, and Carol Buckinger and Fred Gianelli who coordinated their efforts.

PREFACE

California's air quality in many metropolitan areas has deteriorated to the point that residents are concerned enough to rouse their legislators to protect and improve air quality through enaction of new legislation (The Clean Air Act of 1990). While the federal statutes place certain demands on improving California's air quality, California's air quality standards are more rigorous than the federal standards or any other state's standards. The major contributor to air pollution is vehicle emissions. This study focuses on the relationship among land use density, mixture, transit accessibility and vehicle use. The last item stems from travel behavior, which in turn reflects attitudes and behavior patterns. Our need to understand the underlying factors of travel decisions and the attitudes indicating which decision will be made has lead to the undertaking of this study.

We wish to gratefully acknowledge the support of the California Air Resources Board Staff as well as Chuck Purvis of the Metropolitan Transportation Commission (MTC) for providing the San Francisco Bay Area demographic and land use data base for this study. In addition we acknowledge all the graduate and undergraduate students who contributed to the endeavor, including: Ram Pendayala, Bagher Baharder, Sherri Hardiman, Francisca Mar, Prasuna DVG Dornadula, Brandy Olson, Jamie Rundgren, Tom Hoang, Catherine Kawachi, and Tzuoo-Ding (Roger) Lin. In addition we appreciate the logical order and questionnaire syntax suggested by Stephen Potter, of the Open University in London, England, and John Robinson of the University of Maryland. Thanks to Susan O'Bryant for her vigilant oversight of the budget and attention to a myriad of other administrative details.

ABOUT Part I and II

After completing the main report (Part I), we wished to distill some of its key descriptive and model results in a shorter paper for publication. The journal article in Part II is that paper, forthcoming in the *Transportation* journal. Most of the topics in the article are contained within the main report (although sometimes re-packaged in a more summary fashion). The main report, however, contains a great deal more detail. The article in Part II does slightly extend the analysis of the main report by conducting F-tests on the one-by-one exclusion of blocks of attitudinal, neighborhood, and socio-economic variables from a full model containing all types of variables (Table 11 of Part II)

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1. INTRODUCTION

As the air quality in many urban areas of California becomes a pressing issue, the need to reduce vehicular emissions has become more and more acute. Although a wide range of travel demand management (TDM) measures have been adopted to reduce urban vehicular traffic, it is doubtful whether these measures alone are sufficient in rapidly growing urban and suburban areas of California. From the fact that land use patterns are the primary determinants of the distribution of trip origins and trip destinations -- hence trip length and vehicle miles traveled (VMT)--and the fact that the viability of public transit critically depends on land use density, it follows that comprehensive emission reduction measures must embrace policies on land use development.

The understanding of the relationship between land use and travel behavior is unfortunately limited. Widely practiced forecasting procedures assume that household trip generation (the number of trips made by a household per day) is a function of its demographic and socio-economic attributes, while land use density and transit accessibility are assumed to have no impact. The effect of land use on trip generation is assumed to be indirect and is through vehicle ownership.

Unfortunately, models of vehicle ownership used by planning agencies are too simplistic to reflect land use density or transit accessibility. Although household vehicle ownership can be modeled using residential density as one of the explanatory variables, quite often such variables are not incorporated in vehicle ownership forecasting models in use. For example, a model for the Sacramento metropolitan area uses housing unit type as an explanatory variable, which accounts for land use characteristics to only a very limited extent. The effect of land use density and mixture at the neighborhood level has not been established as land use information has been available only at the traffic zone level in traditional transportation studies.

On the other hand, recent research supports the notion that higher population density results in lower vehicle miles traveled by residents (Holtzclaw, 1991). The intent of the Mobility and Livable Communities Study is to extend the past research and determine the independent effect of land use upon travel behavior while incorporating into the scope of the analysis demographic, socio-economic, and transportation level-of-service (LOS) as well as detailed descriptors of land use patterns.

A report by the California Energy Commission (CEC, 1993) claims that over 70% of survey respondents would switch from automobile to walking or bicycling for shopping and personal business trips if the trips were reduced to 1/2 mile in length and bicycle paths and pedestrian walkways were provided. Furthermore, 70% of the people surveyed indicated that they would like to live in a more compact community with these features. The CEC report further noted that, "nationwide, 38% of all vehicle trips are for shopping or personal business. About 60% of these vehicle trips are between 1/2 mile and 5 miles in distance. If half of these trips were shortened to less than 1/2 mile and, subsequently, half of these short trips were made on foot instead of driving, the number of shopping and personal business trips would lessen by about 15%. Total vehicle trips would decline by over 5%. The reduction in VMT and gasoline savings would be closer to 1 - 2%, since shopping and personal business trips under 5 miles only represent about 7% of the total VMT".

Yet, there's no guarantee that these intentions stated by survey respondents in response to hypothetical questions accurately represent behaviors that would be exhibited when the hypothetical situation materializes. Furthermore, it is extremely dangerous to anticipate changes in behavior based on statistical relationships found in data; care must always be exercised to distinguish between "statistical association" and "causal relationship." Observed correlation between land use density and VMT reflects the effects of many interrelated contributing factors such as income, vehicle ownership, and household structure. Therefore increasing land use density may not lead to as much reduction in VMT as the statistical correlation suggests. For example, a planned neighborhood with a specific land use density and configuration may not attract an intended mix of residents, leading to a VMT reduction that differed from what was initially anticipated.

As a comprehensive approach to the relationship between land use and travel, a set of five neighborhoods in a California metropolitan area are selected in this study for in-depth analysis.

The study sites are chosen to produce systematic variations among them in factors such as land use density and mixture, access to freeways, and transit availability. The trip-making behavior of a sample of neighborhood residents is surveyed and correlated to the above factors as well as to demographic and socio-economic characteristics of the household. Sample residents' life-styles and attitudes toward transportation and environmental problems are also incorporated into the analysis. Through the analysis, the study intends to determine differences in travel behavior attributable to land use factors.

The approach of this study, which is a hybrid of the social-scientific case study and large-scale survey research, enables the acquisition of detailed descriptions of land use and transportation service levels, which are essential for the study. At the same time, it facilitates multi-variate statistical analysis based on large sample survey results. The purpose of this research project is to determine the quantitative relationship between the density and configuration of land uses and the emissions (due to vehicle-trips and vehicle-miles traveled) that result. The goal of this research effort is to provide information to suggest whether, and/or in what ways, land-use-related policies will be effective in reducing emissions.

The findings presented in this report were obtained by analysis of the following:

1. a three part mail out/mail back survey including

   a request for participation,

   a household questionnaire, and

   an individual questionnaires with a personal trip diary,

   from a survey conducted as part of this study.

2. Land use maps, road maps, Metropolitan Transportation Commission land use data base, census data and other sources which were used to designate neighborhoods within the study area. These data are used to document the following:

   - study site demographic and socio-economic characteristics,
   - transit service levels,
   - highway accessibility, and
   - land use density and mixture.

3. Information from the site survey.

The main analysis of the study is based on a sample of 953 households chosen randomly from five San Francisco Bay Area communities (area of at least one square mile) within the Metropolitan Transportation Commission's jurisdiction.

2. DAVIS SITE PILOT SURVEY

The Mobility and Livable Communities survey was piloted in Davis, California during the months of June, July, August and September, 1992. The objectives of the pilot survey were to ascertain:

- the effectiveness of the questions in eliciting appropriate responses,
- the effectiveness of an incentive system to increase survey response,
- timing between mailing phases, and
- verification of expected response rates for the additional neighborhoods to be studied.

The final survey design reflects the outcome of the pilot study.

2.1. Survey Description

The pilot study consists of a four phase mail-out/mail-back survey. The purpose of each phase is as follows.

Phase-0 is a one page questionnaire asking the recipient to participate in the study as well as requesting some household demographic information.

Phase-1 consists of a background questionnaire asking for more demographic and socio-demographic information, and trip diaries distributed to household members who are 16 or older.

Phase-2 is concerned with residential history, factors affecting residential and job location choice, perception of the neighborhood, and perceived mode availability and use as reported by a person representing the household, and factual information on household members (those who did not keep diaries), parking, and vehicles available.

Phase-3 establishes the action space of each household member (16 and older), and the mental map by travel mode. Phase-3 also asks attitudinal questions.

One-thousand Phase-0, "Will You Participate", questionnaires were delivered in a predominantly middle-class residential neighborhood of Davis. As well as asking for the household's participation, Phase-0 asked for basic household demographic information. Four-hundred twenty-eight (428) households responded, and 360 households agreed to participate. Following the recruitment phase, 360 Phase-1, the Background questionnaire, and 549 Trip Diaries were mailed (an average of 1.5 persons per household agreed to participate). Three-hundred sixty (360) Phase-2 Household questionnaires were mailed and 264 were returned. In the final phase, Phase-3, 551 questionnaires were mailed and 409 were returned.

The response rate of households agreeing to participate in the Davis pilot was high at 36 percent (the number of households agreeing to participate as a percent of Phase-0 questionnaires mailed). Seventy-three (73) percent of households which agreed to participate completed all three phases of the survey, and 75 percent of the individuals agreeing to participate completed all three phases of the survey.

2.2. Description of the Survey Sample

The minimum age of the survey respondents is 16 and the maximum age is 87. The average household size is 2.66 persons, and the average number of persons per household over 16 years of age is 2.14. On average 1.86 persons per household are employed and there are 3.03 bicycles per household. Of those responding, 97.1% have a driver's license, about 50% work full time, and 23% work part time.

Tables 2.1 and 2.2 show that the sample responding to the survey is older and has higher incomes than would be expected from the census data for the study area. Likewise home ownership is found to be much higher than would be expected from census data. While this is typical for self-administered surveys oft his type, it indicates that the sample is not completely representative of the population as a whole. Gender, on the other hand, is relatively balanced (see Table 2.3) with females slightly over-represented in the sample.

Table 2.1
Comparison of Age Distributions: Davis Sample vs. Census

AGE	SURVEY DATA	1990 CENSUS DATA
16 to 24 years	15.9	40.2
25 to 34 years	14.6	20.8
35 to 44 years	23.9	19.2
45 to 54 years	21.0	10.9
55 to 64 years	12.0	4.8
> 64 years	12.6	4.0
TOTAL*	100.0	99.9
No. of Persons	548	6631

*Total may not add up to 100% due to rounding error.

Table 2.2
Comparison of Household Income Distributions: Davis Sample vs. Census

HOUSEHOLD INCOME	SURVEY DATA	1990 CENSUS DATA
$0 to $5,000	4.2	7.0
$5,001 to $10,000	6.0	10.7
$10,001 to $20,000	4.5	19.3
$20,001 to $35,000	13.6	19.5
$35,001 to $50,000	16.6	16.0
$50,001 to $75,000	21.8	14.5
$75,001 to $150,000	31.5	11.6
> $150,000	1.7	1.4
TOTAL*	99.9	100.0
No. of Households	403	17968

*Total may not equal 100% due to rounding error.

Table 2.3
Comparison of Gender Distribution: Davis Sample vs. Census

GENDER	SURVEY DATA	1990 CENSUS DATA
Male	46.0	49.0
Female	54.0	51.0
Total	100.0	100.0

A total of 416 respondents indicated their means of travel to work and another 123 indicated their means of travel to school. The survey respondents reported that 55.3% drive alone to work and 31.7% drive alone to school (Table 2.4).

Table 2.4
Distribution of Commute Travel Modes: Davis Pilot Survey

TRAVEL MODE	PERCENT EMPLOYED USING	PERCENT STUDENTS USING	TOTAL
Drive Alone	55.3	31.7	49.9
Car/Vanpool	10.6	9.8	10.4
Public Transportation	2.6	6.5	3.5
Bicycle	21.6	43.1	26.5
Walk	2.6	3.3	2.8
Work at Home	7.2	Not applicable	5.6
Ride School Bus	Not applicable	4.9	1.1
Other	0.0	0.8	0.2
TOTAL*	99.9	100.1	100
No. of Persons	416	123	539

*Total may not equal 100% due to rounding error.

2.3. Survey Re-design

Based on results of the Davis pilot survey, the survey instruments were re-designed for the main Bay Area neighborhood surveys. Phase 0 is very similar to the original Phase 0. However, Phases 1, 2 and 3 have been combined into two surveys: an individual survey and a household survey. The trip diary was redesigned to facilitate both completion by the survey participant and data entry. A number of subtle changes have also been made in the survey design based on the results of the Davis pilot survey. The redesigned surveys provide the same information with fewer questions and are easier for the respondents to complete. In addition, having only two main phases leads to a significant saving in the cost of incentives and lower attrition from the beginning to end of the series of surveys. The questionnaires used in both the Davis and Bay Area Surveys can be found in Appendix A. All database information may be found in Appendix C.

3. DESCRIPTION OF BAY AREA STUDY SITES

Detailed land use, roadway network, and public transit information was collected in this study in a set of carefully selected neighborhoods. Each study site is approximately one square mile and defined by major streets. This microscopic information was integrated with demographic, socio-economic, attitudinal, and travel behavior data collected through mail surveys of households in the same neighborhoods. Because only a limited number of neighborhoods could be studied, they needed to be selected through a careful experimental design to yield the maximum amount of information. The procedure of selecting study sites is described in detail in this chapter.

3.1. Site Selection Procedure

The selection procedure utilized the 700-zone land use data base for the nine-county San Francisco Bay Area supplied by the Metropolitan Transportation Commission (MTC). In addition, census data and geographical information available from land use maps, road maps, and other sources were used in the procedure. Factors that are often found to be associated with travel behavior, such as income and residential density, were used in the selection of study sites. In this study, BART access and land use mix were used as additional controlling factors.

The original MTC database was composed of 700 zones. Initial selection of sites for the survey was based on filtering for those zones whose employee population reflected a largely agricultural, manufacturing or retail base, then by performing cross tabulations on population density, median income, and employment. Agricultural, manufacturing and retail percentages were calculated by taking the total number of employees in each category, and dividing by the total number of employees in the zone. Population density was calculated as total population divided by total acres. Employment was calculated as the percentage of total employees per total population. Zones whose percentage of agricultural and manufacturing employment was greater than 5% were dropped from the database, as were zones whose percentage of retail employment was greater than 35%.

In order to gain a set of study sites that facilitate efficient statistical analysis, a strategy was set to obtain study sites that represent extreme values in terms of the controlling factors. This was achieved through the following procedure. A simple univariate analysis was performed on employment, population density and income. Upper and lower bounds were set for zonal income and zonal population density, of one standard deviation from their respective means, and for zonal employment of .35 of a standard deviation from the mean. Cross-tabulations were performed using zonal income and population density to identify zones that lie outside these bounds in categories of: high income with high density, low income with high density, high income with low density, and low income with low density. The same procedure was repeated for employment. Twenty zones were randomly selected from these tables, choosing two or three zones from each table.

From the twenty candidate zones, final selection was performed by correlating the location of the zone with access to transit on a zone map. For example, since San Francisco has access to BART, San Jose was chosen as a contrasting area with low access to mass transit. Zones were chosen for San Francisco reflecting high density with low income, and low density with high income, and corresponding zones were identified and selected from the San Jose area. One zone was selected from San Francisco with high density and high income; no corresponding zone was available from San Jose.

In selecting these sites, it was recognized that land use mix as well as population density is a critical determinant of travel behavior. Site selection was consequently performed considering population density, land use mix, and BART access. Another critical factor, income, was incorporated into the selection procedure by screening out those zones whose median annual incomes lie outside the $28,000 to $34,700 bracket. This was to avoid confounded analysis arising from correlations between income and population density or land use mix across study sites. For example, if the only high-income zone studied were also a high-density zone, it would be difficult to separate the effects of income from density. Thus zonal income was held relatively uniform across study sites while extremes were included in terms of population density and land use mix. Within each zone, however, income will vary across households, permitting the examination of the association between household income and travel behavior.

Nine sites were visited to examine their suitability for the study. A description of these candidate sites can be found in Table 3.1. The following are highlighted observations from the initial site surveys:

- With the exception of zone 266, all zones have a mix of high and low income housing.
- Zone 392 has very high income and very low income. Zone 266 is mostly very low to low income.
- Zone 541 - Daly City - diverse with very low income near the bottom of a hill and very high income in new developments along the ridges and hilltops bordering the San Bruno Mountains.
- The Pleasant Hill BART Station area was determined to be included in zone 98. However, the MTC demographic profile of zone 98 is not compatible with the observed characteristics of the area surrounding the station; specifically, the mean income for zone 98 is $22,585, while the newer multi-family dwellings in that area are, on average, $100.00 more per unit for a one-bedroom apartment than the rest of the neighborhood. We conjecture that the 1990 MTC data might not include information on newer developments, and thus may not reflect a change in mean income for this area.

Because of the difficulty in determining MTC zone boundaries on street maps, zone 392 was surveyed in error. The original zone to be surveyed was zone 393, which has a higher population and a much higher residential density, higher mixed use, and a lower mean income than zone 392.

In assessing relative densities within neighborhoods and between zones, square-footage parameters were used. These are summarized in Table 3.2.

Table 3.1
Bay Area Study Candidate Sites

SITE	BORDER	NAME	DENSITY		LAND USE[3]	MEAN ANNUAL HOUSE-HOLD INCOME ($)	BART ACCESS
			Population[1]	Residential[2]			
Concord 479	North East South West	Concord Blvd Farm Bureau Rd, Babel Ln Cowell Road Monument Blvd	9.5	15.6	0.6	29,187	Northwest corner
Pleasant Hill 98	North East South West	Oak Park Blvd, Mayhew Wy Bancroft Rd Contra Costa Canal Putnam St	7.0	36.2	3.0	22,585	BART in center of zone
North San Francisco 438	North East South West	California St Divisidaro St Fell St Stanyan St, Fulton (East-West), Arguello Blvd	41.4	80.1	.02	44,846	No BART station in zone. Access approximately 1.25 miles away at Civic Center Station.
South San Francisco 392	North East South West	Dewey Blvd, Woodside Ave O'Shaughnessy Blvd, Bosworth Ave Monterey Blvd Santa Clara Ave, Claremont Blvd	18.5	34.1	0.03	40,476	Far Southeast corner
San Jose 232	North East South West	Hillsdale Ave Almaden Dr Branham Ln Meridian Ave	9.	14.	0.	33,891	No BART access

Table 3.1 (continued)
Bay Area Study Candidates Sites

SITE	BORDER	NAME	DENSITY		LAND USE[3]	MEAN ANNUAL HOUSE-HOLD INCOME ($)	BART ACCESS
			Population[1]	Residential[2]			
South San Francisco 393	North East South West	17th St, 16th St Hwy 101 Woodside Ave, Portola Dr, Clipper St, Army St Laguna Honda, Clarendon Ave	21.8	52.0	1.07	29,096	Two access points Middle at South end and Middle at North end
Daly City 541	North East South West	Hillcrest Dr, Mission St, Brunswick St, Hanover, Bellevue Ave South Hill Blvd, Crocker, Hill Dr San Pedro Rd, E Market St, San Bruno Mtns Junipero Serra Blvd	24.9	51.0	0.03	29,700	Northwest corner
San Jose 266	North East South West	Story Rd Clayton Rd, Mt Pleasant Rd, Ruby Ave Tully Rd Capitol Expwy	16.6	29.8	0.06	29,640	No BART access
Castro Valley 181	North East South West	Fairmont Dr Lake Chabot Rd Castro Valley Blvd Foothill Blvd	10.3	17.1	0.05	34,155	No BART access

[1]Number of people per acre of land
[2]Number of people per acre of residential land
[3]Total retail & service employment per total population

Table 3.2
Relative Housing Density

DENSITY	LOT SIZE IN SQUARE FEET PER UNIT	
	SINGLE FAMILY	MULTI-FAMILY
High	6,000 to 8,500	1,000 to 1,500
Medium	10,000 to 15,000	2,000 to 2,500
Low	20,000 to 40,000	3,000

The range for mean zone annual income had originally been set at between $28,000 and $34,700 per year for middle income. However, it became necessary to inject more flexibility into the income range due to realtive purchasing power differences in parts of the Bay Area. The goal was to adhere to a certain standard of living as evidenced by housing and general neighborhood maintenance. Final selection includes the following are the five study sites:

North San Francisco (Zone 438)	Residential density, population density, mixed land use are all high with no BART access in the zone.
South San Francisco (Zone 392)	Residential density and population density are high, and mixed land use is low. There is immediate BART access in the zone. This site offers a good contrast study in land use to the North San Francisco site; its median income is similar to that of North San Francisco.
Concord (Zone 479)	Population density and residential density are low; mixed land use is high. There is BART access in the zone.
Pleasant Hill (Zone 98)	High residential density contrasts with low population density, indicating high degree of mixed use.
San Jose (Zone 232)	Population density and residential density are low; mixed land use is high, with no BART access. This again affords an excellent opportunity to study the effect of mixed land use on travel behavior as a contrast site to the Concord study site. Mean income is similar to Concord.

The experimental design established by these study sites is presented below in Table 3.3.

Table 3.3
Mixed Use, Population Density and BART Access by Zone

Mixed Use	Population Density		BART Access
	Low	High	
Low	Davis		No BART
High	San Jose	N. San Francisco	No BART
Low		S. San Francisco	BART
High	Concord	Pleasant Hill	BART

4. SITE SURVEY DESCRIPTION

Implicit in land use and transportation planning is the philosophy that cities are for people. However, we have continued to aspire to the American Dream of a suburban single-family house on a half-acre lot with a three car garage (Kitamura, 1991). Land development patterns which accommodate these aspirations have played a significant role in shifting the emphasis away from concern for pedestrian or bicycle circulation in favor of automobiles. While these urban development patterns have provided a high level of motor-mobility, walking has often been made unattractive and difficult (Levinson and Smith, 1975).

The automobile, or some form of personal transportation which allows the same freedom of mobility, is here to stay. The concern is to allow for alternate modes of transportation when possible and to ensure a safe environment and avoid congestion for all transportation modes. Street patterns contribute to both a safe environment and decreased traffic congestion. Two street patterns are commonly used in land use design. The first, and more traditional design, is a grid pattern where streets are constructed at approximately 90 degree angles to each other. The second, more recent, pattern is the cul-de-sac layout in which development occurs along a short street with only one entrance and egress, with many cul-de-sacs emptying onto a main arterial street.

Both street patterns have advantages and disadvantages. Some advantages of a grid pattern include: alternate routes are available, there is less congestion, there is not a single collector arterial, distances are shorter for all transportation modes. The disadvantages of a grid design include: vehicle traffic may travel faster than on a cul-de-sac, it may be more difficult for pedestrians or bicycles to cross streets, there is through traffic rather than only local traffic. Advantages of a cul-de-sac street pattern include slower local traffic, less traffic volume on the cul-de-sac than on a grid street or an arterial, no through traffic. Disadvantages include: all cul-de-sacs empty onto an arterial, fewer or no alternate routes available, increased speed and congestion on collector arterial, longer pedestrian and bicycle routes, pedestrian and bicycle safety may be problematic on collector arterials and main arterials.

In this study, travel, attitudinal, and socio-economic data were collected from a random sample of residents in five San Francisco Bay area neighborhoods. Observed differences between neighborhoods in these travel and other characteristics are expected to be correlated in part with different land use characteristics of those neighborhoods. Therefore, site surveys were conducted for each of the neighborhoods to evaluate its attributes in relationship to a safe trip environment for all mode choices as well as to assess congestion potential. The specific elements surveyed included width of streets, frequency and condition of bus stops, Bart stations and train stations (if any), presence of carpool lots, presence and condition of bicycle lanes; presence and width of sidewalks including building setbacks, and visibility and condition of pedestrian crosswalks.

Descriptions of the five study sites are given in this section followed by descriptions of the site survey design and survey results which offer quantitative measures of the neighborhood characteristics at these study sites. A map of the San Francisco Bay Area containing the study sites and maps of the respective sites are given in Appendix B.

4.1. Site Descriptions

Concord

Land Uses: Lying in the San Ramon Valley, the Concord site consists of a flat, wedge-shaped section of primarily two disparate elements. A downtown business district occupies the small western end of the site, into which protrudes the eastern terminus of BART, while the remainder of the site is devoted mainly to single family dwellings.

Circulation: The Contra Costa canal slices unobtrusively southward through the middle of the site. Four streets—Galindo Street, Concord Boulevard, Clayton Road and Cowell Road—radiate from the business district. Clayton Road, however, serves as the site's main artery. Almost bisecting the site, Clayton Road contains virtually all the commercial businesses (excluding downtown) and multi-family dwellings within this neighborhood. The nearest freeway, State Route 242, is one-half mile to the west. A single paved bike trail parallels the canal and, although Cowell Road is designated as a bike route, street markings are absent. Sidewalks, either missing from or discontinuous along many streets, make walking difficult and hazardous.

Pleasant Hill

Land Uses: The only site transected by both a freeway (I-680) and BART, Pleasant Hill lies on the same flat valley floor as the Concord site which is approximately three miles to the northeast. Around a central planned district, which apparently has been given over to office complexes and apartments, multi-family dwellings and commerce predominate. To the west of the freeway along North Main Street and, to a lesser extent, Oak Park Boulevard, neighborhood commercial establishments are allowed. To the east along Treat Boulevard and Buskirk Avenue large office complexes are prevalent. Single family dwellings occur in three distinct, unattached zones within the site. An area of low density multi-family dwellings, separated by the natural boundary of Candelero Creek, occupies the site's eastern corner. Ongoing construction along I-680 at both N. Main Street and Buskirk Avenue indicates that the integration of the freeway and the BART station into the neighborhood is not complete.

Circulation: The Contra Costa canal with a paved bike trail serves as the site's southern boundary and links this site to Concord, as does BART. In addition, the two sites share three bus routes. At both sites transit lines originate at the BART station. Pleasant Hill, however, exhibits a far more heterogenous, even fragmented, configuration. The freeway effectively divides the site and inhibits movement. Only Treat Boulevard allows total east-west flow.

North San Francisco

Land Uses: The most populous of the sites with over 10,000 households, the North San Francisco site also occupies a hillside which culminates in Laurel Heights to the north. Intensely urbanized, the site contains a university, numerous churches and hospitals, and the headquarters for Muni. Without either a BART station or a freeway (I-80 is approximately one mile to the east), the site boasts 21 bus routes. Wide sidewalks accompany each block. The widespread commercial activity is channeled somewhat along Geary Boulevard, the primary east-west artery, and Divisadero Street The site displays the most variegated of land use patterns. Apartment districts tend to adjoin commercial areas and mid-sized apartments often intermix with single family dwellings.

Circulation: The long, linear streets form a rigid grid pattern, which facilitates, even encourages, movement as most streets are through streets. This site invites entry, which may have been the cause for the high level of mixed use. Only Golden Gate Park inhibits north-south traffic flow. North San Francisco furnishes a much different example of hillside adaptation than South San Francisco and of the use of a grid pattern than San Jose.

South San Francisco

Land Uses: In contrast to the previous three sites, the South San Francisco neighborhood wraps around the slopes of Mt. Davidson, whose heavily wooded peak forms a park. As in Concord and San Jose, single family dwellings predominate. Multi-family dwellings are confined to a narrow, disjointed strip at the base of Mt. Davidson along Monterey Boulevard where they intermix with commercial establishments. Other commercial activity occurs primarily in isolated sections near the perimeter, especially near the BART station and along a short stretch of Portola Dr. A few apartments dot the site's interior. Like San Jose, commercial developments are absent within this neighborhood, but are confined to the periphery.

Circulation: A BART station sits at the site's most eastern point and I-280 lies close enough to provide convenient freeway access. Portola Dr. is the site's main artery for there are very few through streets here. Traffic flow stays to the perimeter as in San Jose. The numerous curved streets, conforming to the mountain's slopes, impede movement and protect the neighborhood's seclusion. The rectilinear streets in the southeast contrast with this design and more properly belong with the grid pattern to the south. Also, a modified grid pattern emerges north of Portola Dr. where the land flattens.

San Jose

Land Uses: San Jose's most striking characteristic is its uniformity. Shaped like a rectangle, the San Jose site consists almost exclusively of single family dwellings. A short, narrow band of duplexes is adjacent to the site's eastern boundary, while within the site only schools and parks break up the homogeneity of the residential pattern. Commercial areas, small and discrete, are confined to three corners of the site and along Branham Ln., which acts as the main commercial artery.

Circulation: Capitol Expressway forms the eastern boundary so freeway access is immediate. A BART line is lacking, but a light-rail system runs three miles to the east of this site. Five bus routes service the site, but only along the perimeter. Only two streets, Jarvis Avenue and Cherry Avenue, transect the site north-south and none in an east-west direction, giving traffic flow a strong north-south bias. Streets are strikingly similar to each other in their characteristics and the overall configuration suggests a highly modified grid pattern.

4.2. Site Survey Design

The original site survey for the Davis study area furnished the basic format for the Bay Area site surveys. Since the Davis survey involved only 1,000 households and 10 streets, modifications of the survey design were necessary in order to analyze the far larger and more populous Bay Area sites in an efficient and comprehensive manner. Businesses and parks/schools were treated as separate categories. Due to the larger number of apartments and the time constraints of the survey, information on apartments included just the address and number of units. Detailed bus and BART schedules were obtained for each site and maps showing bus stops, bus routes, traffic signs and signals, and land use patterns were included, similar to the Davis survey (see Appendix B).

The street survey itself was altered substantially both to facilitate the formatting of the data and to focus on the specific characteristics of the street which were most relevant to the project's purposes. The sheer number of streets, businesses, apartments and transit schedules mandated that as much information as possible should be obtained and presented in an accessible, coherent format. Thus, the design of the site survey attempts to be comprehensive and readable by employing eight major categories for describing a site and thirteen characteristics for delineating each street.

4.3. Site Survey

The site survey included a number of pre-survey preparations. Land use, zoning and road maps were obtained for each site, as well as transit maps and schedules. Additional information on apartments, bike trails, social and cultural amenities, open space and urban general plans was acquired whenever possible. From this information a survey route was designed in order to expedite data collection and identify possible complex areas.

The survey was conducted by teams of two persons mostly by driving through the study sites in a vehicle. Using maps to keep track of the survey's progress, each street in each site was traversed at least once. Highly commercial streets, wide arterial streets and areas of mixed land use were surveyed with two to four trips in order to collect adequately the high level of information. In some areas the survey was done on foot.

The survey concentrated on the following information: physical street characteristics, associated neighborhood features (sidewalks, lighting, etc.), traffic signs and signals, the location of bus stops, the identification of apartments and schools, parks and open space, and the tabulation of businesses by their primary activity. To simplify the survey process, street characteristics were recorded which prevailed along the length of the street. All observations were made during the day and each site was visited at least twice.

The tapes used to record information on each site were transcribed using the site survey format and, together with the previously amassed maps and site information, formed the core of the survey report for each site. Street length was measured from a map. BART and bus schedules furnished the data for transit routes and times. Businesses were grouped first by street and then by street number. The number of units in an apartment was determined by direct inspection on the street, from literature gathered at the site and with the aid of post office information. In addition, the telephone book was a useful tool in deciphering incomplete, missing or confusing addresses. The tapes supplied the information needed to construct maps of bus stops and traffic signals, while the transit booklets served as reference for maps of bus lines. Land use maps were derived primarily from zoning maps and, to a smaller extent, the general plan for a site, when available.

4.4. Results of the Site Survey

The findings of the site survey for each case study are included as an appendix to this report and include a detailed physical description of every street in each site together with transit schedules, apartment and business listings, public facilities and maps showing bus stops, traffic signs, bus routes and zoning maps. This detailed, particular information in conjunction with a broader perspective provided by street configuration and land use patterns allows the analysis of neighborhood characteristics, traffic circulation and land use variations among the five sites. Summary information characterizing the five Bay Area study sites can be found in Table 4-1.

Even a cursory look at the zoning maps leads to several observations. Despite different street configurations, Concord, San Jose, and South San Francisco have large contiguous areas of single family dwellings. South San Francisco and North San Francisco each display different urban adaptations to a hillside environment. Regarding commercial uses and apartments, the Concord, San Jose and South San Francisco sites have small, concentrated pockets of commercial use and relatively few apartments. Both North San Francisco and Pleasant Hill have just the opposite characteristics -- long commercial zones along major streets and an abundance of apartments.

Street patterns vary widely: a strict grid in the North San Francisco site, short and winding streets befitting the hillside location of the South San Francisco site, primary streets radiating from a business hub in the Concord site, a rectangular variation of the grid system in the San Jose site, a lack of any prevailing pattern in the Pleasant Hill site.

Concord changes abruptly from its western business district, which is dominated by office complexes and a BART station with few directional and informational signs to the surrounding quiet neighborhoods. Since north-south movement is difficult within this neighborhood, the radial streets, especially Clayton Road, carry the traffic flow through the site (hierarchical street pattern). Concentrated retail and multi-family areas along one street further insulates the study site neighborhood. Beginning near the BART station and moving eastward, the street pattern undergoes successive changes from a straightforward grid to an incomplete rectangular grid to long, linear streets with more curves and rounded angles. Similar changes occur in the northern part of the site and give rise to a succession of small, discrete neighborhoods protected by the overall configuration of the site and the prevailing land use patterns.

Table 4.1
Study Site Characteristics Summary

Site Characteristic	CONCORD	PLEASANT HILL	NORTH SAN FRANCISCO	SOUTH SAN FRANCISCO	SAN JOSE
Street Pattern	Radiating	Fragmented	Grid	Curved, rectilinear, grid	Discontinuous, grid
Topography	Flat	Flat	Hills	Hill, flat	Flat
Business Location	Western end of site	Central near BART and Freeway	Throughout the site	Monterey Blvd and near perimeter	3 Corners of site
Freeway Access	Hwy 242 1/2 mile west	I-680 transects site	I-80 one mile east	I-280 to east	Capitol Expressway on eastern boundary
BART Access	West side of site	Center site	None	Southeast corner of site	None
Bus Lines	Three routes	Three routes	21 bus routes	One route	Five routes along perimeter
Main Street Name(s)	Galindo, Concord, Clayton, Cowell	Treat Blvd	Geary, Divisadero	Portola Dr	Branham
Main Street Direction	East-West	East-West	North-South and East-west	North-South	North-South
Bike Trails	Parallel to Contra Costa Canal and along Cowell Rd No Street Markings	Parallel to Contra Costa Canal at southern boundary	None	None	None marked
Sidewalks	Missing, Discontinuous	Discontinuous	Wide	Narrow, Discontinuous	Missing
Walking	Hazardous	Hazardous	Common	Difficult	Hazardous

San Jose achieves a comparable isolation in a different manner. Retail activity, as well as a minor two-family zone, are relegated to the site's periphery, while apartments are completely absent. San Jose is the most uniform of the sites, with over 90% of the streets having the same characteristics except for street length. The variations in street length conceal the underlying grid pattern which has been dissolved into diverse rectangular shapes. Such an arrangement discourages movement into and within the site and instead directs flow to the boundary streets. North-south movement prevails and reflects the orientation of the expressway and the light-rail system 3 miles to the east. In maintaining the integrity of its homogeneous structure within the confines of four major arterial streets, the San Jose site functions like an island neighborhood in an urban sea.

South San Francisco, the third site with a large area devoted to single family dwellings, also confines both commercial and multi-family zones to the periphery. The only major through street, Portola Dr., cuts diagonally across the site to the north, rather than into it. The winding streets around Mt. Davidson conform to the hilly terrain and contrast sharply with the linear, gridded streets of North San Francisco. Movement is most convenient along the boundary streets, for this street configuration also impedes flow into the site and helps to secure a measure of tranquility and isolation for the neighborhood. Even the freeway and a BART station occupy inconspicuous locations at the site's eastern edge.

As noted earlier, the North San Francisco site exemplifies a simple but strict grid pattern which has been imposed on the hillside unlike the graceful adaptation of the South San Francisco site or the more irregular grid of the San Jose site. Such a configuration of linear through streets appears to facilitate movement which befits an area with large commercial and multi-family zones. Moreover, a university and hospitals demand easy access and rapid movement. The primary flow is east-west along California Street, Geary Boulevard, which also has seven bus lines, Turk Boulevard and Fulton Street. A freeway's terminus to the west causes traffic to spill onto Fell Street, Masonic Avenue and Divisadero Street are major arteries, while the barrier of Golden Gate Park diminishes north-south flow. The high degree of mixed use complements the open structure of the site and the predictability of a consistent grid pattern.

With an intrusive freeway and a centrally located BART station with limited facilities for pedestrian access, the Pleasant Hill site is more a collection of urban fragments than a neighborhood. The disconnected street configuration and the three disjoined single family zones add to this. The lack of a clear street pattern and the fragmented nature of its land use zones reflect the disruptive, uncertain transition that this site appears to be undergoing. Only one east-west street, Treat Boulevard/Geary Road, and only one north-south street, N. Main Street, allow movement through the site. High density multi-family zones and commercial areas are scattered about the central planned unit district which has been given over to office buildings and apartments. A low density retirement community sits in isolation on the site's eastern side.

5. ANALYSIS OF BAY AREA HOUSEHOLD DATA

Characteristics of the Bay Area sample households are presented in this chapter. The population representativeness of the sample households and individuals is examined first with respect to age, sex, education level, and income. Following this, housing characteristics are compared across the study sites. Finally, perceptual factors pertinent to residential choice behavior are explored.

5.1. Population Representativeness

The respondents of the travel diary survey reasonably represent the study area in terms of gender. The gender distribution is practically identical to that in the census in most study sites (Table 5.1). The small chi-square (χ^2) values and the large values of α shown in the table imply that there is no basis to reject the null hypothesis that the distributions in the survey sample are statistically identical to those in the census (The χ^2 statistics is a measure of the difference between two frequency distributions, in this case the gender distribution in the survey sample and that in the census data. The larger the χ^2 value, the more different are the two distributions. The value of α in the table represents the probability that a χ^2-value greater than the one shown above will be obtained under the null hypothesis that the two distributions are identical. A large α (i.e., close to 1.0) thus implies that one is likely to be correct when accepting the null hypothesis. When α is small (close to 0), on the other hand, the χ^2 value is unusually large and the sample distribution and the theoretical (in this case census) distribution are distinct. It is therefore appropriate to reject the null hypothesis. In this case, α represents the probability that one is incorrect when rejecting the null hypothesis, i.e., the event that the null hypothesis in fact is true despite the large χ^2 value.)

The sample age distribution adequately represents the population in South San Francisco, Pleasant Hill, and San Jose (Table 5.2). However, the tendency is clear that individuals in the younger age groups (16 to 24 and 25 to 34) are under-represented in most study sites, especially in Concord, while oldest age groups tend to be over-represented.

Table 5.1
Comparison of Gender Distributions Between Survey and Census Data

SITE	CONCORD		PLEASANT HILL		NORTH SAN FRANCISCO		SOUTH SAN FRANCISCO		SAN JOSE	
GENDER	Survey	Census	Survey	Census	Survey	Census	Survey	Census	Survey	Census
Female	49.0	51.0	55.0	52.5	52.7	50.5	46.7	52.5	53.7	50.0
Male	51.0	49.0	45.0	47.5	47.3	49.5	53.3	47.6	46.3	49.9
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.1	100.0	99.9
χ^2	.10		.12		.10		.67		.26	
α	.75		.73		.74		.41		.61	
Sample Size	192	9472	220	22105	224	33087	227	29715	244	9428

Table 5.2
Comparison of Age Distributions Between Survey and Census Data

SITE	CONCORD		PLEASANT HILL		NORTH SAN FRANCISCO		SOUTH SAN FRANCISCO		SAN JOSE		TOTAL	
AGE	Survey	Census	Survey	Census	Survey	Census	Survey	Census	Survey	Census	Survey	Census
16 to 24	5.8	12.5	2.3	11.8	3.2	48.2	3.1	10.8	7.0	13.5	4.3	14.3
25 to 34	8.9	24.9	23.5	30.0	27.9	29.2	10.2	17.2	16.1	24.9	17.5	25.1
35 to 44	23.6	21.4	18.0	19.7	30.2	18.7	26.2	22.0	18.2	22.0	23.2	20.4
45 to 54	23.0	13.5	18.4	12.1	17.6	10.5	24.9	15.3	16.1	16.5	19.9	13.0
55 to 64	18.3	10.3	18.9	9.6	10.4	6.8	14.7	13.0	23.6	12.6	17.2	9.9
>64	20.4	17.3	18.9	16.7	10.8	15.8	20.9	21.8	19.0	10.5	18.0	17.4
TOTAL	100.0	100.0	100.0	100.0	100.0	100.00	100.0	100.0	100.0	100.0	100.0	100.0
χ^2	15.1		12.4		42.7		8.9		12.48		6.3	
α	.02		.05		.00		.18		.05		.39	
Sample Size	191	7596	217	14479	222	31148	225	24883	242	7312	1097	85418

The Bay Area sample shares the tendency of most mail surveys to over-represent individuals with higher education (Table 5.3). The sample distribution of education levels is significantly different (at $\alpha = 0.05$) from that in the census data for all study sites except Pleasant Hill. In all study sites, individuals without a high school diploma and individuals with a high school diploma as a terminal degree are noticeably under-represented in the survey sample. Likewise, low income households are under-represented in the survey sample (Table 5.4) as is commonly true for mail surveys.

The analysis of this section points to the need to develop appropriate weights that are to be applied to the sample households or individuals so that results derived from the sample will properly represent the population. This is not performed in the analyses presented in this report and remains as a future task.

Table 5.3
Comparison of Education Levels
Between Survey and Census Data

HIGHEST EDUCATION LEVEL	CONCORD		PLEASANT HILL		NORTH SAN FRANCISCO		SOUTH SAN FRANCISCO		SAN JOSE	
	Survey	Census	Survey	Census	Survey	Census	Survey	Census	Survey	Census
< High School Diploma	4	14	2	8	1	15	5	12	3	13
High School Diploma	16	32	8	17	5	16	4	18	10	24
Some College	38	34	33	35	29	28	25	29	41	38
Bachelor's Degree	32	15	38	29	41	27	37	24	33	20
Advanced Degree	11	5	18	11	25	15	28	17	13	6
TOTAL	101	100	99	100	101	101	99	100	100	101
Sample Size	298	7454	295	14282	234	25226	293	24217	341	7044
χ^2	19.57		9.25		24.15		16.99		18.27	
α	.00061		.05747		.00007		.00194		.00109	

Table 5.4
Comparison of Household Income Distributions Between Survey and Census Data

INCOME	CONCORD		PLEASANT HILL		NORTH SAN FRANCISCO		SOUTH SAN FRANCISCO		SAN JOSE	
	Survey	Census	Survey	Census	Survey	Census	Survey	Census	Survey	Census
1 to 5,000	0.0	2.1	1.0	1.8	1.71	6.2	0.6	2.6	1.6	1.24
5,001 to 10,000	1.1	7.0	1.0	3.6	1.7	9.5	0.6	5.2	0.5	3.4
10,001 to 20,000	6.7	13.7	6.7	8.4	6.9	14.6	3.3	7.0	5.3	9.5
20,001 to 35,000	21.9	19.2	23.0	20.5	21.7	24.1	10.4	14.9	13.8	9.4
35,001 to 50,000	22.5	20.5	27.3	24.5	26.9	18.1	16.9	16.0	21.2	15.4
50,001 to 75,000	27.5	23.0	23.9	21.9	24.0	16.0	29.5	24.4	33.3	27.8
75,001 to 150,000	19.7	13.6	16.8	17.1	13.1	9.3	32.2	23.2	23.8	32.2
>150,000	0.6	0.9	0.5	2.2	4.0	2.3	6.6	6.8	0.5	1.2
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sample Size	178	2460	209	7211	175	16074	183	11445	189	1375

5.2. Housing Characteristics

Housing characteristics in the five Bay Area study sites are examined in this section to gain further insights into each neighborhood and the differences among them. The distribution of monthly rents is given by study site in Table 5.5. The number of missing observations shown in the table approximately represents the number of households that do not rent their homes. Most sample households own their homes in Concord, South San Francisco, and San Jose, while the North San Francisco sample consists largely of renters and the Pleasant Hill sample also contains a significant fraction of renters. The rent distribution for North San Francisco is very dispersed, suggesting the availability of a wide range of housing units in the area. This contrasts sharply with the tight distribution found for the Pleasant Hill site which contains many large apartment complexes.

Table 5.5
Distribution of Reported Monthly Rents

RENT ($/Month)	CONCORD	PLEASANT HILL	NORTH S.F.	SOUTH S.F.	SAN JOSE	TOTAL
<350	2	1	7	2	2	14
351 to 500	3	1	16	3	3	26
501 to 700	8	31	34	2	1	76
701 to 1,000	7	28	44	8	10	97
1,001 to 1,400	0	9	14	8	3	34
>1,400	0	1	3	0	0	4
Missing*	163	142	65	166	179	715
TOTAL	183	213	183	189	198	966

*The row titled "Missing" contains those people who own their own homes.

The distributions of reported home values (Table 5.6) confirm the observation from the site surveys that the San Jose study site is very homogeneous, with over 95% of reported home values falling in the range of $180,000 to $375,000. The South San Francisco site, on the other hand, exhibits a much wider spread with its mode in the $250,000 to $375,000 range. The North San Francisco site shows a similar distribution with a mode in the $375,000 to $575,000 range. The number of missing observations is quite high for North San Francisco presumably due to the higher fraction of renters in this study sites. Pleasant Hill and Concord have distributions with lower reported home values, with modes in the $180,000 to $250,000 range.

As one may expect from the distributions of home values and rents, the San Jose site is very homogeneous in terms of the number of bedrooms, with 93.8 of the sample households having either three or four bedrooms. The Concord site is also relatively homogeneous with 60.2 of the sample households having three bedrooms. The North San Francisco and Pleasant Hill sites have more disperse distributions that are skewed toward fewer numbers of bedrooms, probably a reflection of the higher fractions of renters in these sites. The South San Francisco sample exhibits a disperse distribution with a mode at three bedrooms.

Table 5.6
Distribution of Reported Home Values

HOME VALUE	CONCORD		PLEASANT HILL		NORTH SAN FRANCISCO		SOUTH SAN FRANCISCO		SAN JOSE		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<80,000	0	0.0	3	1.4	0	0.0	1	0.5	0	0.0	4	0.3
80,000 to 120,000	8	4.4	21	9.8	0	0.0	2	1.1	1	0.5	35	3.0
120,000 to 180,000	49	26.8	31	14.5	6	3.3	4	2.1	5	2.5	125	10.7
180,000 to 250,000	79	43.2	55	25.7	7	3.8	18	9.5	72	36.4	306	26.2
250,000 to 375,000	25	13.7	29	13.6	14	7.7	76	40.2	98	49.5	319	27.3
375,000 to 575,000	1	0.6	4	1.9	22	12.0	43	22.8	2	1.0	87	7.5
575,000 to 775,000	0	0.0	0	0.0	6	3.3	16	8.5	0	0.0	22	1.9
>775,000	0	0.0	0	0.0	5	2.7	6	3.2	0	0.0	11	0.9
Missing	21	11.5	71	33.2	123	67.2	23	12.2	20	10.1	258	22.1
TOTAL	183		214		183		189		198		1167	100.0

The results of this section in general confirm the findings from the site survey and add to them that the North San Francisco site, and the Pleasant Hill site to a lesser extent, contain large fractions of renters. The San Jose site is very homogeneous in terms of housing value and housing unit size, while the South San Francisco site is very diverse. The Pleasant Hill and North San Francisco households tend to have smaller housing units in terms of the number of bedrooms. The Concord site is also relatively homogeneous, and shares with the Pleasant Hill site a distribution with lower home values, on average, than the other areas.

Table 5.7
Distribution of the Number of Bedrooms

NO. OF BEDROOMS	CONCORD	PLEASANT HILL	NORTH SAN FRANCISCO	SOUTH SAN FRANCISCO	SAN JOSE	% OF TOTAL
0	0.0	0.0	2.9	0.0	0.0	0.5
1	2.2	17.5	34.5	4.3	0.5	11.3
2	17.7	38.7	37.4	31.6	2.6	25.0
3	60.2	35.4	14.6	45.5	44.3	39.3
4	18.2	7.6	7.6	17.1	49.5	19.7
5	1.1	0.9	1.8	1.1	3.1	1.6
6	0.6	0.0	0.0	0.5	0.0	0.2
7	0.0	0.0	1.2	0.0	0.0	0.2
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
Sample Size	183	214	183	189	198	967

5.3. Residential Location

"Housing cost," "quiet neighborhood" and "safety and security" are indicated most frequently as the most important reasons why the sample households chose their current homes (Table 5.8a). Those indicated as the second and third most important reasons are shown in Tables 5.8b and 5.8c, respectively. The frequency distribution of the three most important reasons collectively, is shown in Table 5-9 for the 10 most often cited reasons.

Table 5.9 shows that, following these three reasons, proximity to public transit, work, and shops and services are indicated as important reasons for residential location. Affordability ("housing cost") appears to be the most decisive factor, followed by the living quality of the neighborhood ("quiet neighborhood" and "safety and security"), and accessibility ("close to transit," "close to work" and "close to shops and services'). Amenities ("style of housing units" and "spacious residential neighborhood") and "good school" follow. The proximity to freeways is ranked low partly because some neighborhoods in the study sites do not have good freeway access. The fact that the sample households from the Concord and San Jose study sites that are well served by freeways also rank the factor low, however, suggests that freeway access is taken either for granted or not important in urban residents' residential choice.

The Concord sample shows a frequency distribution that approximates the combined distribution for all sites. In this sense the Concord sample is representative of all sites. "Safety and security," however, is ranked low, and despite the proximity to BART, proximity to transit is also ranked rather low.

The Pleasant Hill respondents are unique in that a large number of them indicated proximity to transit (95 respondents) and proximity to freeways (35 respondents) as one of the three most important reasons for residential location. In fact, proximity to transit is the second most frequently cited reason after housing cost among the Pleasant Hill respondents. It may be concluded that mobility is a major consideration for those who chose to live in Pleasant Hill.

Being in a "quiet neighborhood," which is the second most frequent reason, is only the sixth most frequent reason among the respondents from the North San Francisco site. "Close to transit," "close to work" and "close to shops and services" are all almost as frequently cited as "safety and security." The North San Francisco sample residents appear to have preferred accessibility to opportunities over quietness in the neighborhood. "Quiet neighborhood," on the other hand, is most frequently cited by the South San Francisco residents. "Spacious residential neighborhood" is also more frequently indicated by this group.

The San Jose site is unique because "close to transit" is least frequently cited by its sample respondents. After the same three most frequent reasons as in the sample-wide distribution, "style of housing units" is the fourth most frequent reason. This is followed by "close to shops and services" and "good school," suggesting the family-orientation of the San Jose sample.

Table 5.8a
First Most Important Reason for Selecting the Current Home

RESPONSES	CONCORD		PLEASANT HILL		NORTH SAN FRANCISCO		SOUTH SAN FRANCISCO		SAN JOSE		TOTAL	
No Response	6	3.3	5	2.3	1	0.6	9	4.8	13	6.6	34	3.5
Quiet Neighborhood	37	20.2	24	11.2	19	10.6	32	17.0	33	16.7	145	15.1
Safety and Security	7	3.8	27	12.6	28	15.6	27	14.4	21	10.6	110	11.4
Close to Work	11	6.0	20	9.4	7	3.9	6	3.2	6	3.0	50	5.2
Close to Transit	7	3.8	28	13.1	6	3.4	10	5.3	1	0.5	52	5.4
Nicely Landscaped Area	0	0.0	1	0.5	0	0.0	1	0.5	5	2.5	7	0.7
Housing Cost	68	37.2	63	29.4	64	35.8	52	27.7	70	35.4	317	33.0
Lively Neighborhood	1	0.6	0	0.0	1	0.6	0	0.0	1	0.5	3	0.3
Good School	8	4.4	5	2.3	6	3.4	6	3.2	5	2.5	30	3.1
Close to Freeway	1	0.6	5	2.3	2	1.1	1	0.5	2	1.0	11	1.1
Close to Shops and Services	1	0.6	2	0.9	11	6.2	1	0.5	1	0.5	16	1.7
Spacious Res. Neighborhood	10	5.5	6	2.8	0	0.0	13	6.9	3	1.5	32	3.3
Liked Style of Housing Units	10	5.5	12	5.6	8	4.5	14	7.5	21	10.6	65	6.8
Other	8	4.4	8	3.7	13	7.3	3	1.6	7	3.5	39	4.1
Lot/housing Availability	0	0.0	0	0.0	1	0.6	0	0.0	0	0.0	1	0.1
Investment Value	0	0.0	2	0.9	0	0.0	1	0.5	2	1.0	5	0.5
Shared Community Values	1	0.6	1	0.5	2	1.1	2	1.1	0	0.0	6	0.6
Close to Park, Grnblt, Bike	0	0.0	0	0.0	1	0.6	1	0.5	0	0.0	2	0.2
Lot Size	1	0.6	2	0.9	0	0.0	0	0.0	0	0.0	3	0.3
Close to Family/friends	2	1.1	2	0.9	3	1.7	1	0.5	3	1.5	11	1.1
Allows Pets	0	0.0	0	0.0	1	0.6	0	0.0	0	0.0	1	0.1
Family/child Home/nbrhd	3	1.6	0	0.0	1	0.6	1	0.5	2	1.0	7	0.7
Character of Nbrhd/ngbrs	1	0.6	1	0.5	2	1.1	3	1.6	2	1.0	9	0.9
View	0	0.0	0	0.0	2	1.1	2	1.1	0	0.0	4	0.4
TOTAL	183	100.0	214	100.0	179	100.0	186	98.9	198	100.0	960	99.8

Table 5.8b
Second Most Important Reason for Selecting the Current Home

RESPONSES	CONCORD		PLEASANT HILL		NORTH SAN FRANCISCO		SOUTH SAN FRANCISCO		SAN JOSE		TOTAL	
Not applicable	0	0.0	1	0.5	7	3.9	2	1.1	3	1.5	13	1.4
No Response	7	3.8	6	2.8	0	0.0	8	4.3	11	5.6	32	3.3
Quiet Neighborhood	26	14.2	26	12.2	14	7.8	30	16.0	34	17.2	130	13.5
Safety and Security	12	6.6	29	13.6	23	12.9	34	18.1	38	19.2	136	14.1
Close to Work	29	15.9	18	8.4	28	15.6	15	8.0	11	5.6	101	10.5
Close to Transit	16	8.7	29	13.6	27	15.1	30	16.0	0	0.0	102	10.6
Nicely Landscaped Area	4	2.2	3	1.4	1	0.6	4	2.1	4	2.0	16	1.7
Housing Cost	28	15.3	22	10.3	24	13.4	22	11.7	30	15.2	126	13.1
Lively Neighborhood	2	1.1	0	0.0	2	1.1	0	0.0	1	0.5	5	0.5
Good School	11	6.0	13	6.1	2	1.1	8	4.3	20	10.1	54	5.6
Close to Freeway	5	2.7	13	6.1	4	2.2	5	2.7	4	2.0	31	3.2
Close to Shops and Services	13	7.1	22	10.3	21	11.7	9	4.8	16	8.1	81	8.4
Spacious Residential Nbrhood	10	5.5	5	2.3	3	1.7	12	6.4	2	1.0	32	3.3
Liked the Style of Housing Units	14	7.7	17	7.9	12	6.7	6	3.2	13	6.6	62	6.4
Other	4	2.2	6	2.8	4	2.2	2	1.1	7	3.5	23	2.4
Lot/housing Availability	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Investment Value	0	0.0	0	0.0	0	0.0	0	0.0	1	0.5	1	0.1
Shared Community Values	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Close to Park, Grnbelt, Bike Tr.	0	0.0	1	0.5	3	1.7	0	0.0	0	0.0	4	0.4
Lot Size	1	0.6	1	0.5	0	0.0	0	0.0	0	0.0	2	0.2
Close to Family/friends	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Allows Pets	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Family/childhood Home/nbrhood	0	0.0	0	0.0	2	1.1	0	0.0	0	0.0	2	0.2
Character of Nbrhood, Neighbors	1	0.6	2	0.9	1	0.6	0	0.0	3	1.5	7	0.7
View	0	0.0	0	0.0	1	0.6	1	0.5	0	0.0	2	0.2
TOTAL	183	100.0	214	100.0	179	100.0	188	100.0	198	98.5	962	100.0

Table 5.8c
Third Most Important Reason for Selecting the Current Home

RESPONSES	CONCORD		PLEASANT HILL		NORTH SAN FRANCISCO		SOUTH SAN FRANCISCO		SAN JOSE		TOTAL	
Not Applicable	0	0.0	1	0.5	7	3.9	2	1.1	3	1.5	13	1.4
No Response	7	3.8	6	2.8	0	0.0	8	4.3	11	5.6	32	3.3
Quiet Neighborhood	26	14.2	26	12.2	14	7.8	30	16.0	34	17.2	130	13.5
Safety and Security	12	6.6	29	13.6	23	12.9	34	18.1	38	19.2	136	14.1
Close to Work	29	15.9	18	8.4	28	15.6	15	8.0	11	5.6	101	10.5
Close to Transit	16	8.7	29	13.6	27	15.1	30	16.0	0	0.0	102	10.6
Nicely Landscaped Area	4	2.2	3	1.4	1	0.6	4	2.1	4	2.0	16	1.7
Housing Cost	28	15.3	22	10.3	24	13.4	22	11.7	30	15.2	126	13.1
Lively Neighborhood	2	1.1	0	0.0	2	1.1	0	0.0	1	0.5	5	0.5
Good School	11	6.0	13	6.1	2	1.1	8	4.3	20	10.1	54	5.6
Close to Freeway	5	2.7	13	6.1	4	2.2	5	2.7	4	2.0	31	3.2
Close to Shops and Services	13	7.1	22	10.3	21	11.7	9	4.8	16	8.1	81	8.4
Spacious Residential Neighborhood	10	5.5	5	2.3	3	1.7	12	6.4	2	1.0	32	3.3
Liked the Style of Housing Units	14	7.7	17	7.9	12	6.7	6	3.2	13	6.6	62	6.4
Other	4	2.2	6	2.8	4	2.2	2	1.1	7	3.5	23	2.4
Lot/housing Availability	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Investment Value	0	0.0	0	0.0	0	0.0	0	0.0	1	0.5	1	0.1
Shared Community Values	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Close to Park, Grnbelt, Bike Tr.	0	0.0	1	0.5	3	1.7	0	0.0	0	0.0	4	0.4
Lot Size	1	0.6	1	0.5	0	0.0	0	0.0	0	0.0	2	0.2
Close to Family/friends	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Allows Pets	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Family/childhood Home/neighborhood	0	0.0	0	0.0	2	1.1	0	0.0	0	0.0	2	0.2
Character of Neighborhood, Neighbors	1	0.6	2	0.9	1	0.6	0	0.0	3	1.5	7	0.7
View	0	0.0	0	0.0	1	0.6	1	0.5	0	0.0	2	0.2
TOTAL	183	100.0	214	100.0	179	100.0	188	100.0	198	98.5	962	100.0

Table 5.9
The Three Most Important Reasons for Selecting Current Home

	CONCORD	PLEASANT HILL	NORTH SAN FRANCISCO	SOUTH SAN FRANCISCO	SAN JOSE	TOTAL
Housing Cost	113	107	95	83	118	516
Quiet Neighborhood	97	75	45	97	99	413
Safety and Security	33	70	64	87	76	330
Close to Transit	41	95	61	65	8	270
Close to Work	54	47	60	35	31	227
Close to Shops and Services	35	51	62	31	46	225
Style of Housing Units	33	46	37	28	49	193
Good School	30	23	12	16	43	124
Spacious Res. Neighborhood	31	17	6	34	8	96
Close to Freeway	11	35	13	17	13	89
TOTAL	183	214	179	188	198	962

6. ASSOCIATION BETWEEN STUDY AREA CHARACTERISTICS AND TRIP RATES BY MODE

The analysis of this section focuses on the association between selected measures of individuals' travel behavior obtained from the three-day travel diary and various measures of study area characteristics. Both objective measures of neighborhood characteristics obtained by the research team and subjective measures reported by the respondents are included in the analysis. The objective of this section is to quantitatively assess how much land use characteristics, transit accessibility and other neighborhood characteristics affect travel demand, in particular vehicular travel demand.

As measures of travel demand, the analysis of this section focuses on:

- total number of person trips,
- number of transit trips,
- number of non-motorized trips,
- fraction of automobile trips,
- fraction of transit trips, and
- fraction of non-motorized trips.

The individual, not the household, is used in the analysis of this study because of the advantage that attributes specific to individuals can be incorporated into the analysis, in particular the attitudes toward transportation, environment and energy problems or other pertinent aspects of urban life (see Chapter 8). Note that the analysis is for those individuals who were over 16 years old at the time of the survey and from whom trip-diary data are available.

Quantitative models are developed to explain the variations in, and predict the future values of, these travel demand measures using demographic and socio-economic attributes of the sample households and their members, along with the following measures of land use characteristics:

- study area dummy variables,
- macroscopic area descriptors,
- pedestrian/bicycle facilities indicators,
- housing choice indicators,
- microscopic accessibility indicators, and
- perceptions of living quality.

Note that these measures are by no means independent of each other, but tend to represent the same or overlapping aspects of land use in different manners. These land use descriptors are explained below.

Study Area Dummy Variables

These are 0-1 dummy variables that identify which study area each respondent is from. Variable names used in the analysis are:

North San Francisco
South San Francisco
Concord
Pleasant Hill
San Jose

Each variable takes on a value of 1 if the respondent comes from the study area indicated by the variable name; otherwise the variable will take on a value of 0. For example, the variable, "North San Francisco" will equal 1 if the respondent is from the North San Francisco study area. The variable for San Jose is omitted in all models because of the linear dependency among these variables. This is equivalent to setting the model coefficient for San Jose as 0 as a reference point.

Macroscopic Area Descriptors

The variables included in this group are:

BART Access
Mixed Land Use
High Density

These variables are also 0-1 dummy variables that are defined based on the factors considered during the site selection process. As Table 3.3 of Chapter 3 indicates, BART Access is 1 for South San Francisco, Concord and Pleasant Hill respondents, and 0 for North San Francisco and San Jose respondents. Mixed Land Use is 1 for North San Francisco, Concord, Pleasant Hill, and San Jose respondents, and 0 for those from South San Francisco. Finally High Density is 1 for North San Francisco, South San Francisco, Pleasant Hill, and 0 for Concord and San Jose.

Pedestrian/Bicycle Facilities

This group consists of the following two variables,

Sidewalk
Bike Path

The first variable is a 0-1 dummy variable defined in terms of the response to the following question (Q. 9) in Phase 1, Household Questionnaire, Part B, "Are there sidewalks in your neighborhood?" and takes on a value of 1 if the response is affirmative. The second variable is also a 0-1 dummy variable defined based on the response to "Are there bike paths in your neighborhood?" (Q. 10, Part B, Household Questionnaire).

Housing Choice Indicators

This group comprises the following three 0-1 dummy variables:

Backyard
Parking Spaces Available
Own Home

The first variable is defined by the response to "Do you have a private backyard?" and the third variable by the response to "Do you own your home?" (Q. 10 and Q. 11, Part A, Household Questionnaire). The second variable, Parking Spaces Available, is defined by their response to "How many parking spaces are available exclusively for your household use? Include your garage and driveway" (Q. 14, Part B, Household Questionnaire).

Microscopic Accessibility Indicators

Included in this group are:

Distance to Nearest Bus Stop
Distance to Nearest Rail Station
Distance to Nearest Grocery Store
Distance to Nearest Gas Station
Distance to Nearest Park

These variables are respectively defined based on the responses to the following five questions (Q. 7, Q. 8, and Q. 16a, 16b and 16c) in Part B of the Household Questionnaire:

> "How far away, to the nearest tenth of a mile, is the bus stop nearest your home?"
>
> "How far away, to the nearest tenth of a mile, is the BART, Amtrak, CalTrain, or light rail station nearest to your home?"
>
> "Approximately how far (in miles) is your home from the nearest:
>
> a. Grocery store?
> b. Gas station?
> c. Park or playground?"

All measurements are in miles.

Perceptions of Living Quality

The following six variables are in this group:

No Reason to Move
Streets Pleasant for Walking
Cycling Pleasant
Good Local Transit Service
Enough Parking
Problems of Traffic Congestion

The first variable, no reason to move, is a 0-1 dummy variable that takes on a value of 1 if the respondent responded with "No reason to move at this time" to the question, "Given your current neighborhood situation, which of the following reasons may make you consider moving to a different area? (Check all that apply.)" (Q. 5, Part A, Household Questionnaire). The following five variables are also 0-1 dummy variables and are defined respectively based on the responses to the questions (Q. 1 through Q. 5, Part B, Household Questionnaire):

> "Are the streets in your neighborhood pleasant for walking or jogging?"
> "Is cycling pleasant in your neighborhood?"
> "Is there good local public transit service in your neighborhood?"
> "Is there enough parking near your home?" and
> "Are there problems of traffic congestion in your neighborhood?"

In the rest of this section, models formulated for the measures of travel demand listed above are discussed. In the discussion, a "base model" is presented for each measure, the effects of the above six groups of variables are individually examined, then a best model is presented. Both the base models and best models are developed considering a wide range of variables representing the characteristics of the household, individual, and the neighborhood. The base models are constructed using only household and person demographic and socio-economic attributes, while the best models incorporate selected variables from the above six variable groups. The best models were, however, formulated independent of the estimation results using the six variables groups. Consequently there are occasions where the "best" model does not have the best goodness of fit. The set of variables considered in model development is given in Table 6.1.

Total Number of Person Trips

The base model explains slightly below 15% of the total variation in the number of person trips made by an individual over a three-day period (see Table 6.2). Despite the fact that the dependent variable of the model is the number of trips made by individuals, household size and number of persons over 16 years old turned out to be factors that significantly affect personal trip generation. The coefficients of these two variables together indicate that an individual over 16 years old from a household with an individual younger than 16 years old tends to make 2.62 more trips than one from a household without individuals in the younger age group; while an individual from a household with another individual of 16 years old or over tends to make 0.35 fewer (= 2.618 - 2.966) trips.

Table 6.1
Variables Used in the Analysis of Section 6

Household size
Number of persons over 16 years old
Number of cars
Number of cars per persons over 16 years old
Annual household income in $10,000
Square root of annual household income in $10,000
Number of years lived in the Bay Area
Drivers license holding
Age in years divided by 10
Square root of age divided by 10
Female dummy variable
Employment dummy variable
Homemaker dummy variable
Student dummy variable
Professional dummy variable
Low education dummy variable (up to high school diploma)
College education dummy variable
High education dummy variable (some graduate school or graduate degree)
Graduate education dummy variable (completed graduate degree)
Personal income dummy variables
Apartment dummy variable
Single family home dummy variable (including duplexes and triplexes)

Note: The variables in the six variable groups discussed earlier in the section are not included in this table.

Table 6.2
Linear Regression Models of the Total Number of Person Trips

	Base Model		Area Dummy Variables		Macro Area Descriptors		Pedestrian/ Bike Facilities	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	2.308		1.230		1.348		1.795	
Household Size	2.618	8.92	2.755	9.29	2.722	9.19	2.614	8.89
Persons Over 16 Yrs. Old	-2.966	-6.68	-2.976	-6.66	-2.991	-6.69	-2.954	-6.63
Cars per Person	-0.094	-0.17	0.084	0.15	0.045	0.08	-0.129	-0.23
Driver's License	2.473	2.27	2.522	2.32	2.455	2.26	2.452	2.25
Age Divided by 10	-0.225	-2.53	-0.249	-2.79	-0.239	-2.68	-0.226	-2.53
Employment Dummy Variable	0.369	0.59	0.226	0.36	0.238	0.38	0.343	0.54
Student Dummy Variable	3.565	2.77	3.404	2.65	3.445	2.68	3.556	2.76
High Education Dummy Variable	0.658	1.31	0.586	1.17	0.579	1.15	0.654	1.30
Household Income (in $10,000)	-0.887	-2.53	-0.977	-2.77	-0.959	-2.72	-0.894	-2.54
$(\text{Household Income})^{1/2}$	5.282	2.95	5.697	3.18	5.636	3.14	5.345	2.98
North San Francisco			2.312	2.64				
South San Francisco			0.257	0.37				
Concord			-0.223	-0.33				
Pleasant Hill			0.361	0.53				
BART Access					-0.880	-1.67		
Mixed Land Use					0.430	0.65		
High Density					1.215	2.22		
Sidewalk							0.347	0.56
Bike Path							0.348	0.74
Backyard								
Parking Spaces Available								
Own Home								
Distance to Nearest Bus Stop								
Distance to Nearest Rail Station								
Dist. to Nearest Grocery Store								
Dist. to Nearest Gas Station								
Dist. to Nearest Park								
No Reason to Move								
Streets Pleasant for Walking								
Cycling Pleasant								
Good Local Transit Service								
Enough Parking								
Problems of Traffic Congestion								
R^2	0.1471		0.1572		0.1544		0.1479	
F	13.37		10.28		10.85		11.18	
D.F.	10, 775		14, 771		13, 772		12, 773	
α	< 0.00005		< 0.00005		< 0.00005		< 0.00005	
F for the Group	-		2.308		2.221		0.358	
D.F.	-		4, 771		3, 772		2, 773	
Significance (* = 5%, ** = 1%)	-							

Table 6.2 (Continued)

	Housing Choice		Accessibility		Perception of Living Quality		Best Model	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	1.879		2.599		1.933		2.022	
Household Size	2.682	9.03	2.610	8.84	2.599	8.71	2.835	9.62
Persons Over 16 Yrs. Old	-2.908	-6.55	-2.963	-6.59	-2.932	-6.52	-3.013	-7.07
Cars per Person	0.251	0.44	-0.098	-0.17	-0.122	-0.22		
Driver's License	2.615	2.41	2.549	2.33	2.442	2.23	2.805	2.66
Age Divided by 10	-0.220	-2.49	-0.229	-2.54	-0.214	-2.38	-0.232	-2.64
Employment Dummy Variable	0.276	0.44	0.378	0.60	0.241	0.38		
Student Dummy Variable	3.327	2.60	3.497	2.71	3.441	2.65	3.260	2.56
High Education Dummy Variable	0.608	1.22	0.655	1.30	0.672	1.33		
Household Income (in $10,000)	-0.937	-2.68	-0.907	-2.58	-0.933	-2.64	-0.979	-2.81
(Household Income)$^{1/2}$	5.552	3.11	5.379	3.00	5.520	3.06	5.791	3.27
North San Francisco							1.863	2.39
South San Francisco								
Concord								
Pleasant Hill								
BART Access								
Mixed Land Use								
High Density								
Sidewalk								
Bike Path								
Backyard	1.253	1.67						
Parking Spaces Available	-0.320	-3.18					-0.261	-2.73
Own Home	-0.766	-1.16						
Distance to Nearest Bus Stop			0.075	0.07				
Distance to Nearest Rail Station			-0.026	-0.15				
Dist. to Nearest Grocery Store			-0.420	-0.91				
Dist. to Nearest Gas Station			-0.208	-0.47				
Dist. to Nearest Park			0.066	0.21				
No Reason to Move					-0.560	-1.18		
Streets Pleasant for Walking					0.088	0.11		
Cycling Pleasant					0.215	0.41		
Good Local Transit Service					0.572	0.99		
Enough Parking					-0.320	-0.53		
Problems of Traffic Congestion					0.079	0.16		
R^2	0.1613		0.1496		0.1510		0.1622	
F	11.42		9.03		8.55		16.69	
D.F.	13, 772		15, 770		16, 769		9, 776	
α	< 0.00005		< 0.00005		< 0.00005		< 0.00005	
F for the Group	4.342		0.452		0.574		-	
D.F.	3, 772		5, 770		6, 769		-	
Significance (* = 5%, ** = 1%)	**						-	

Quite importantly, the model estimation results indicate that household vehicle ownership, here represented by the number of automobile per person over 16 years old, is not significantly associated with the number of trips per person, made by household members of over 16 years of age. The results also show that employment does not significantly affect trip generation either. Nor did high education dummy variable, which was introduced to the model to account for possible correlation between trip reporting and education, turn out to be significant.

Holding a driver's license is positively associated with person trip generation. Age, on the other hand, is negatively associated with person trip rates with the number of person trips tending to decrease as the person's age increases. The two income coefficients together imply a non-linear income effect which is concave and reaches its maximum at around an annual income of $90,000.

The study area dummy variables as a group contribute an additional 1% to the total variation explained. North San Francisco dummy variable has a positive and significant coefficient; other things being equal, a North San Francisco resident would make 2.31 trips more per three days than does a counterpart in the San Jose study area, whose dummy variable is suppressed from the model to facilitate model estimation. With an F-statistic of 2.31 with degrees of freedom of (4, 771), these variables as a group is significant at $\alpha = 10\%$ but not at $\alpha = 5\%$.

Estimation results indicate that respondents form the high density study areas on average reported 1.22 trips more per three days than did their counterparts in the low density study areas. The indicator of land use mix has an insignificant coefficient, while that of BART access is negative and significant at $\alpha = 10\%$. These variables are as a group is not significant $\alpha = 5\%$. The indicators of the presence of pedestrian and bicycle facilities, constructed based on the respondents' reports, turned out to be insignificant at any rate. Thus the number of trips generated by a person inclusive of all modes, is not associated with the presence of these facilities as perceived by the respondents.

The number of person trips is strongly and negatively associated with the number of parking spaces available to the household. The coefficient of backyard dummy variable is positive and significant at $\alpha = 10\%$, indicating that a person from a household with a backyard tend to make more trips. Home ownership has a negative coefficient estimate, which turned out to be insignificant at $\alpha = 10\%$. This set of variables as a group is significant at $\alpha = 1\%$.

None of the microscopic accessibility indicators is significant. As a group, they have an F-statistic of 0.452 with degrees of freedom of (15, 770), a value that indicates that their effect is not at all statistically significant. The results here thus support the notion that person trip generation is not a function of the proximity to opportunity or accessibility to public transit. Some of the analysis presented below, on the other hand, indicate that the same cannot be said for trip generation by mode and for modal split.

None of the variables that represent perceptions of living quality is individually significant at $\alpha = 10\%$, nor are they significant as a group.

The best model selected for the total number of person trips contains as its explanatory variables: household size, number of persons over 16 years old, driver's license holding, age, student dummy variable, annual household income, square root of annual household income, North San Francisco dummy variable, and number of parking spaces available. Altogether the model explains 16.2% of the total variation in the dependent variable and is highly significant.

The coefficient estimates of these explanatory variables are relatively stable across the models presented in the table. As before, the model coefficients indicate that individuals from households with persons below 16 years old tend to make more trips, while those from households with persons over 16 years tend to make fewer trips. The number of trips tends to decrease with age, while those with a driver's license tend to make more trips. Students on average make 3.26 trips more over a three-day period than their non-student counterparts. Again, the effect of annual household income is non-linear and concave, peaking at approximately \$90,000 per year. Other things being equal, North San Francisco residents make on average 1.86 trips more over three days than their counterparts from the other study areas, and those with more parking spaces available exclusively to their households tend to make fewer trips.

Number of Transit Trips

The models formulated for the number of transit trips are summarized in Table 6.3. Unlike the case for the total number of person trips, household size has an insignificant coefficient, while number of cars and driver's license holding both have significant negative coefficients. Transit trip generation appears to decrease slightly with age, but with a t-statistic of -1.41, the coefficient estimate is not significant. Employment and education are both correlated with transit trip generation, with employment dummy variable, professional dummy variable and high personal income dummy variable having positive coefficient estimates, while graduate school dummy variable having a negative coefficient. Another significant variable is the number of years lived in the Bay Area, which has a highly significant and negative coefficient estimate. Other things being equal, those individuals from households that had been in the Bay Area longer tended to make fewer transit trips. This is against the expectation that those who lived longer in the Bay Area tend to have more information about public transit and would tend to use it more frequently. It could be argued that those who moved to the area recently are more motivated to actively seek information about public transit and use it.

The study area dummy variables improves the percentage of the variation explained from 11.84% of the base model to 12.99%. All four dummy variables in the model have similar coefficient estimates and significant at $\alpha = 5\%$, except for North San Francisco dummy variable which is significant at $\alpha = 10\%$. They indicate that, other things being equal, residents from these four study areas tend to make about 0.45 transit trip more than do their counterparts from San Jose. As noted earlier, a dummy variable for San Jose is excluded from the model to avoid linear dependency. For interpreting the values of the four coefficient estimates, it can be assumed that the coefficient for San Jose is set to 0 as a reference point. The study area dummy variables as a group are significant at $\alpha = 5\%$.

Among the macro area descriptors, BART access dummy variable has a positive and significant (at $\alpha = 5\%$) coefficient estimate. This group of variables as a set is significant at $\alpha =$ 5%. The pedestrian/bike facilities variables have positive coefficient estimates but are not significant. Turning to the housing choice indicators, estimation results indicate that those from households with a backyard tended to make fewer transit trips (the coefficient estimate significant at $\alpha = 5\%$).

Table 6.3
Linear Regression Models of the Number of Transit Trips

	Base Model		Area Dummy Variables		Macro Area Descriptors		Pedestrian/ Bike Facilities	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	2.154		1.592		1.532		1.998	
Household Size	-0.059	-0.72	-0.037	-0.45	-0.044	-0.53	-0.058	-0.71
Persons Over 16 Yrs. Old	0.293	2.17	0.296	2.16	0.300	2.19	0.307	2.26
No. of Cars	-0.526	-6.34	-0.489	-5.77	-0.494	-5.83	-0.536	-6.40
Driver's License	-0.740	-2.46	-0.692	-2.30	-0.705	-2.35	-0.749	-2.48
Age Divided by 10	-0.035	-1.41	-0.032	-1.27	-0.029	-1.18	-0.035	-1.40
Employment Dummy Variable	0.309	1.59	0.295	1.52	0.300	1.55	0.314	1.60
Professional Dummy Variable	0.320	2.02	0.314	1.99	0.306	1.94	0.315	1.99
Graduate School Dummy Variable	-0.408	-2.79	-0.411	-2.81	-0.401	-2.81	-0.405	-2.77
High Personal Income Dummy Variable	0.384	2.53	0.367	2.39	0.369	2.40	0.399	2.62
Years in Bay Area Divided by 10	-0.144	-4.05	-0.136	-3.73	-0.140	-3.86	-0.142	-3.99
North San Francisco			0.427	1.72				
South San Francisco			0.456	2.38				
Concord			0.436	2.34				
Pleasant Hill			0.555	2.90				
BART Access					0.320	2.18		
Mixed Land Use					0.154	0.84		
High Density					0.229	1.48		
Sidewalk							0.085	0.48
Bike Path							0.147	1.14
Backyard								
Parking Spaces Available								
Own Home								
Distance to Nearest Bus Stop								
Distance to Nearest Rail Station								
Dist. to Nearest Grocery Store								
Dist. to Nearest Gas Station								
Dist. to Nearest Park								
No Reason to Move								
Streets Pleasant for Walking								
Cycling Pleasant								
Good Local Transit Service								
Enough Parking								
Problems of Traffic Congestion								
R^2	0.1184		0.1299		0.1287		0.1199	
Standard Error of Estimation	1.727		1.720		1.720		1.728	
F	10.30		8.13		8.68		8.69	
D.F.	10, 767		14, 763		13, 764		12, 765	
α	< 0.00005		< 0.00005		< 0.00005		< 0.00005	
F for the Group	-		2.524		3.019		0.675	
D.F.	-		4, 763		3, 764		2, 765	
Significance (* = 5%, ** = 1%)	-		*		*			

Table 6.3
(Continued)

	Housing Choice		Accessibility		Perception of Living Quality		Best Model	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	2.414		2.523		1.920		2.858	
Household Size	-0.004	-0.05	-0.069	-0.84	-0.060	-0.73		
Persons Over 16 Yrs. Old	0.258	1.90	0.284	2.11	0.269	1.97	0.258	2.42
No. of Cars	-0.466	-5.41	-0.506	-6.08	-0.502	-5.93	-0.476	-5.75
Driver's License	-0.714	-2.38	-0.722	-2.41	-0.759	-2.52	-0.650	-2.20
Age Divided by 10	-0.032	-1.28	-0.031	-1.25	-0.039	-1.55		
Employment Dummy Variable	0.247	1.27	0.320	1.66	0.304	1.56		
Professional Dummy Variable	0.318	2.01	0.304	1.94	0.345	2.16	0.395	2.79
Graduate School Dummy Variable	-0.424	-2.91	-0.396	-2.72	-0.408	-2.79	-0.417	-2.90
High Personal Income Dummy Variable	0.417	2.72	0.359	2.37	0.333	2.18	0.370	2.47
Years in Bay Area Divided by 10	-0.114	-3.02	-0.154	-4.34	-0.140	-3.69	-0.139	-3.97
North San Francisco								
South San Francisco								
Concord								
Pleasant Hill								
BART Access								
Mixed Land Use								
High Density								
Sidewalk								
Bike Path								
Backyard	-0.414	-1.98					-0.593	3.13
Parking Spaces Available	-0.041	-1.45						
Own Home	-0.046	-0.25						
Distance to Nearest Bus Stop			-0.372	-1.12				
Distance to Nearest Rail Station			-0.124	-2.50			-0.141	-3.01
Dist. to Nearest Grocery Store			-0.155	-1.21				
Dist. to Nearest Gas Station			0.163	1.29				
Dist. to Nearest Park			-0.126	-1.44			-0.211	-2.52
No Reason to Move					0.012	0.08		
Streets Pleasant for Walking					0.314	1.48		
Cycling Pleasant					-0.203	-1.37		
Good Local Transit Service					0.305	1.91		
Enough Parking					-0.097	-0.58		
Problems of Traffic Congestion					-0.135	-0.99		
R^2	0.1282		0.1371		0.1271		0.1386	
Standard Error of Estimation	1.720		1.714		1.725		1.707	
F	8.64		8.07		6.92		12.34	
D.F.	13, 764		15, 762		16, 761		10, 767	
α	< 0.00005		< 0.00005		< 0.00005		< 0.00005	
F for the Group	2.884		3.308		1.267		-	
D.F.	3, 764		5, 762		6, 761		-	
Significance (* = 5%, ** = 1%)	*		**				-	

The microscopic accessibility indicators substantially improves the model's fit to an R^2-value of 13.71%. All variables have negative coefficient estimates as expected, indicating that transit trip generation increases as the proximity to transit stops or that to opportunities increases (the latter represents both land use density and mixture). The most significant variable is distance to nearest rail station (significant at $\alpha = 5\%$). The fact that these variables as a group contribute substantially to the model's fit while individually they have insignificant t-values, implies the presence of multi-collinearity among these variables. The F-statistic for the group of variables indicates that they as a group are significant at $\alpha = 1\%$.

The variables representing perceptions of living quality are not significantly associated with public transit trip generation. Among the explanatory variables included in the best model, number of cars have the largest t-statistic value and its association with public transit generation is strongly negative. The variables selected from the six groups are: backyard dummy variable, distance to nearest rail station, and distance to nearest park. It is clear from the estimation results that public transit use is closely associated with the proximity to transit stops. The significance of backyard dummy variable and distance to nearest park suggests that residential density and mixture are also associated with transit use.

Number of Non-Motorized Trips

The inclusion of this particular mobility measure as a dependent variable of the analysis is motivated by the desire to assess the effect of land use characteristics and pedestrian and bicycle facilities on the generation of non-motorized trips. It was believed that the results of the analysis would aid in the development of guidelines for the creation of neighborhoods that are conducive of walking and bicycle trips and thereby produce less needs for vehicular trips.

As the small R^2 values and F-statistics of these models indicate (Table 6.4), this dependent variable is difficult to model. The base model indicates that the number of automobiles available to the household is negatively associated with the number of non-motorized trips (significant at $\alpha = 5\%$). The number of years in the Bay Area is also negatively associated with non-motorized trip generation (significant at $\alpha = 10\%$). The effect of annual household income is again non-linear and concave with a peak at around $55,000.

The study area dummy variables substantially improve the model's fit to an R^2 of 4.73%. They as a group are significant at $\alpha = 1\%$. North San Francisco dummy variable has the largest coefficient estimate of 1.488; other things being equal, North San Francisco residents tend to make about 1.5 walking or bicycle trips more per three days than do San Jose residents. It can be safely inferred that the high density in the North San Francisco area does contribute to this high non-motorized trip generation rate. Note that the effects of auto ownership, household size and other demographic and socio-economic factors are accounted for in the model. Therefore the effects implied by the coefficients of the study area dummy variables are not due to differences in these demographic and socio-economic factors across the areas.

Among the macroscopic area descriptors, high density dummy variable has a significant (at $\alpha = 5\%$) positive coefficient, supporting the above observation of the contribution of high land use density to the generation of non-motorized trips. As a group, they are not significant at $\alpha = 5\%$.

Of the pedestrian/bicycle facilities indicators, sidewalk dummy variable is significant (at $\alpha = 10\%$) and positive. The two variables as a group are also significant $\alpha = 5\%$. The model thus offers evidence that having sidewalks in the neighborhood does contribute to the generation of non-motorized trips.

The model with the housing choice indicators suggests that residents in low density suburban areas tend to make fewer non-motorized trips. Likewise the microscopic accessibility indicators indicate that residents in high accessibility areas tend to make more non-motorized trips. Although individual t-statistics are small, these variables as a group substantially contribute to the model's explanatory power.

As was the case in the previous models, the variables representing perceptions of living quality tend to be insignificant and do not very much contribute to the model's fit. There is an indication that those who perceive that they have good local transit service tend to make more non-motorized trips, but the coefficient estimate of good local transit service dummy variable is not significant at $\alpha = 10\%$.

The best model suggests that the North San Francisco study area possesses characteristics that are conducive of non-motorized trips. The fact that this area indicator is included implies that other contributing factors, such as residential density, mixed land use, or accessibility, do not have large enough a contribution individually, but that the North San Francisco area has a combination of these factors that lead to a large enough and unique contributing force. Sidewalk dummy variable is significant in this model; other things being equal, residents in neighborhood with sidewalks tend to make nearly 0.6 non-motorized trip more over three days than do their counterparts in neighborhoods without sidewalks. The coefficient estimate of BART access dummy variable also indicates that residents in the study areas with BART access (South San Francisco, Concord and Pleasant Hill) tend to make more non-motorized trips.

The analysis of this dependent variable indicates that neighborhood characteristics, such as the presence of sidewalks, do affect the generation of non-motorized trips. The effects of demographic and socio-economic attributes of the household or individual do not have dominating effects on the generation of walk or bicycle trips. The results suggest that urban residents' travel behavior may be modified to some extent by site planning that encourage walking or the use of bicycles.

Fraction of Automobile Trips

The models used for this and the two dependent variables that follow take on the form,

$$n/N = 1/[1 + \exp(-\beta'X)]$$

where

- n = number of trips of interest, in this case the number of automobile trips,
- N = total number of trips,
- β = vector of coefficients, and
- X = vector of explanatory variables.

This can be transformed to yield

$$ln(n/(N - n)) = \beta'X$$

where *ln* is the natural-log transformation. This will take on the form of a linear regression model if $ln(n/(N - n))$ is used as the dependent variable. This, however, creates difficulty when either n is

Table 6.4
Linear Regression Models of the Number of Non-motorized Trips

	Base Model		Area Dummy Variables		Macro Area Descriptors		Pedestrian/ Bike Facilities	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	0.395		-0.663		-0.217		-0.428	
Household Size	0.145	1.49	0.205	2.07	0.175	1.77	0.152	1.56
No. of Cars	-0.302	-2.76	-0.237	-2.13	-0.254	-2.26	-0.311	-2.81
Driver's License	-0.189	-0.43	-0.083	-0.19	-0.153	-0.35	-0.206	-0.47
Age Divided by 10	-0.013	-0.35	-0.027	-0.75	-0.018	-0.50	-0.017	-0.45
Student Dummy Variable	-0.506	-0.95	-0.590	-1.12	-0.583	-1.10	-0.529	-1.00
Professional Dummy Variable	0.254	1.27	0.269	1.35	0.238	1.19	0.225	1.13
Household Income (in $10,000)	-0.231	-1.61	-0.275	-1.93	-0.258	-1.80	-0.249	-1.73
(Household Income)$^{1/2}$	1.106	1.51	1.281	1.77	1.216	1.67	1.224	1.68
Years in Bay Area Divided by 10	-0.097	-1.88	-0.058	-1.10	-0.073	-1.39	-0.086	-1.66
North San Francisco			1.488	4.14				
South San Francisco			0.588	2.06				
Concord			0.341	1.26				
Pleasant Hill			0.426	1.51				
BART Access					-0.197	-0.92		
Mixed Land Use					0.096	0.35		
High Density					0.594	2.63		
Sidewalk							0.558	2.20
Bike Path							0.372	1.95
Backyard								
Parking Spaces Available								
Own Home								
Distance to Nearest Bus Stop								
Distance to Nearest Rail Station								
Dist. to Nearest Grocery Store								
Dist. to Nearest Gas Station								
Dist. to Nearest Park								
No Reason to Move								
Streets Pleasant for Walking								
Cycling Pleasant								
Good Local Transit Service								
Enough Parking								
Problems of Traffic Congestion								
R^2	0.0256		0.0473		0.0350		0.0343	
Standard Error of Estimation	2.583		2.560		2.575		2.574	
F	2.305		2.998		2.373		2.541	
D.F.	9, 789		13, 785		12, 786		11, 787	
α	0.0147		0.0003		< 0.00005		0.0037	
F for the Group	-		4.466		2.538		3.541	
D.F.	-		4, 785		3, 786		2, 787	
Significance (* = 5%, ** = 1%)	-		**				*	

Table 6.4
(Continued)

	Housing Choice		Accessibility		Perception of Living Quality		Best Model	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	0.356		0.905		0.083		-0.149	
Household Size	0.173	1.75	0.132	1.36	0.143	1.45		
No. of Cars	-0.240	-2.12	-0.311	-2.81	-0.283	-2.52		
Driver's License	-0.117	-0.27	-0.131	-0.30	-0.181	-0.41		
Age Divided by 10	-0.010	-0.28	-0.010	-0.28	-0.016	-0.44		
Student Dummy Variable	-0.582	-1.09	-0.522	-0.99	-0.580	-1.08		
Professional Dummy Variable	0.261	1.30	0.265	1.33	0.257	1.27		
Household Income (in $10,000)	-0.242	-1.69	-0.248	-1.73	-0.252	-1.75		
(Household Income)$^{1/2}$	1.212	1.66	1.176	1.61	1.203	1.64		
Years in Bay Area Divided by 10	-0.055	-0.99	-0.103	-1.98	-0.093	-1.66		
North San Francisco							1.494	4.43
South San Francisco								
Concord								
Pleasant Hill								
BART Access							0.662	2.90
Mixed Land Use								
High Density								
Sidewalk							0.584	2.29
Bike Path								
Backyard	0.066	0.21						
Parking Spaces Available	-0.079	-1.90						
Own Home	-0.435	-1.55						
Distance to Nearest Bus Stop			-0.677	-1.42				
Distance to Nearest Rail Station			-0.002	-0.03				
Dist. to Nearest Grocery Store			-0.145	-0.76				
Dist. to Nearest Gas Station			-0.182	-0.96				
Dist. to Nearest Park			-0.211	-1.61				
No Reason to Move					0.020	0.09		
Streets Pleasant for Walking					0.055	0.17		
Cycling Pleasant					-0.097	-0.44		
Good Local Transit Service					0.364	1.54		
Enough Parking					-0.117	-0.48		
Problems of Traffic Congestion					-0.065	-0.32		
R^2	0.0348		0.0428		0.0292		0.0306	
Standard Error of Estimation	2.576		2.568		2.588		2.566	
F	2.360		2.501		1.569		8.376	
D.F.	12, 786		14, 784		15, 783		3, 795	
α	0.0055		0.0017		0.0764		< 0.00005	
F for the Group	2.488		2.807		0.479		-	
D.F.	3, 786		5, 784		6, 783		-	
Significance (* = 5%, ** = 1%)			*				-	

0 or N - n is 0 since the logarithm cannot be defined in that case. To avoid this, a small value, say 0.5, can be added to the numerator and denominator. Thus the regression models here use as their dependent variable the natural log of the number of automobile trips plus 0.5, divided by the number of non-automobile trips plus 0.5.

Cars per person and driver's license holding are the dominant explanatory variables of the base model, associated positively with the fraction of auto trips (Table 6.5). Other variables do not have significant coefficients.

The study area dummy variables are highly significant (at $\alpha = 1\%$ as a group). They together improves the R^2 value from 9.65% of the base model to 13.97%. North San Francisco and South San Francisco have the largest negative coefficients, with Concord and Pleasant Hill following them in that order. As before, San Jose is excluded from the model and have a reference coefficient value of 0. The income variables have significant coefficients in this model. The income effect implied by the coefficients is non-linear and convex; annual household income contributes negatively first until it reaches about $65,000, beyond which point income starts contributing positively to the fraction of auto trips.

Of the macroscopic area descriptors, high density dummy variable has a significant negative coefficient estimate. They as a group are significant at $\alpha = 1\%$.

The pedestrian/bicycle facilities indicators are insignificant and contribute very little to the model's explanatory power.

Among the housing choice indicators, parking spaces available has a positive and very significant (at $\alpha = 1\%$) coefficient. Own home dummy variable is also significant (at $\alpha = 10\%$). Consistent with the earlier indication by high density dummy variable, home owners with ample parking spaces, who tend to live in low density suburbs, are more inclined to make auto trips. This set of variables is significant as a group at $\alpha = 1\%$.

Table 6.5
Linear Regression Models of the Fraction of Car Trips

	Base Model		Area Dummy Variables		Macro Area Descriptors		Pedestrian/ Bike Facilities	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	-0.721		0.176		-0.477		-0.663	
Cars per Person	0.636	4.14	0.506	3.31	0.532	3.44	0.620	4.01
Driver's License	2.263	6.92	2.134	6.65	2.194	6.75	2.243	6.85
Age Divided by 10	0.007	0.28	0.020	0.75	0.010	0.37	0.010	0.36
Employment Dummy Variable	0.069	0.37	0.123	0.67	0.114	0.61	0.083	0.44
Student Dummy Variable	0.185	0.49	0.219	0.59	0.205	0.54	0.192	0.50
High Education Dummy Variable	0.073	0.49	0.148	1.01	0.144	0.98	0.084	0.56
Household Income (in $10,000)	0.142	1.36	0.207	2.01	0.192	1.84	0.150	1.43
(Household Income)$^{1/2}$	-0.704	-1.33	-0.960	-1.84	-0.902	-1.71	-0.729	-1.37
North San Francisco			-1.357	-5.41				
South San Francisco			-0.946	-4.67				
Concord			-0.512	-2.63				
Pleasant Hill			-0.366	-1.87				
BART Access					0.053	0.34		
Mixed Land Use					0.279	1.43		
High Density					-0.424	-2.68		
Sidewalk							-0.106	-0.57
Bike Path							0.108	0.77
Backyard								
Parking Spaces Available								
Own Home								
Distance to Nearest Bus Stop								
Distance to Nearest Rail Station								
Dist. to Nearest Grocery Store								
Dist. to Nearest Gas Station								
Dist. to Nearest Park								
No Reason to Move								
Streets Pleasant for Walking								
Cycling Pleasant								
Good Local Transit Service								
Enough Parking								
Problems of Traffic Congestion								
R^2	0.0965		0.1397		0.1146		0.0979	
Standard Error of Estimation	1.877		1.837		1.862		1.878	
F	10.39		10.47		9.12		8.42	
D.F.	8, 778		12, 774		11, 775		10, 776	
α	< 0.00005		< 0.00005		< 0.00005		< 0.00005	
F for the Group	-		9.709		5.278		0.588	
D.F.	-		4, 774		3, 775		2, 776	
Significance (* = 5%, ** = 1%)	-		**		**			

Table 6.5
(Continued)

	Housing Choice		Accessibility		Perception of Living Quality		Best Model	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	-0.970		-1.244		-0.720		-2.064	
Cars per Person	0.473	3.05	0.618	4.06	0.574	3.72	0.504	3.31
Driver's License	2.194	6.80	2.250	6.97	2.299	7.07	2.224	7.08
Age Divided by 10	0.003	0.12	0.002	0.09	0.010	0.36		
Employment Dummy Variable	0.188	1.00	0.041	0.22	0.078	0.41		
Student Dummy Variable	0.243	0.65	0.174	0.46	0.330	0.87		
High Education Dummy Variable	0.133	0.91	0.041	0.28	0.083	0.56	0.117	0.83
Household Income (in $10,000)	0.169	1.64	0.128	1.25	0.173	1.66		
(Household Income)$^{1/2}$	-0.905	-1.73	-0.589	-1.13	-0.825	-1.56		
North San Francisco								
South San Francisco								
Concord								
Pleasant Hill								
BART Access								
Mixed Land Use								
High Density								
Sidewalk								
Bike Path								
Backyard	0.001	0.00						
Parking Spaces Available	0.120	4.07					0.119	4.28
Own Home	0.378	1.92						
Distance to Nearest Bus Stop			1.142	3.65			0.880	3.31
Distance to Nearest Rail Station			0.037	0.70				
Dist. to Nearest Grocery Store			0.017	0.12				
Dist. to Nearest Gas Station			-0.153	-1.17				
Dist. to Nearest Park			0.235	2.54			0.239	2.77
No Reason to Move					0.109	0.78		
Streets Pleasant for Walking					-0.463	-2.02		
Cycling Pleasant					0.434	2.75		
Good Local Transit Service					-0.307	-1.80		
Enough Parking					0.426	2.42		
Problems of Traffic Congestion					0.186	1.30		
R^2	0.1271		0.1280		0.1190		0.1429	
Standard Error of Estimation	1.849		1.850		1.861		1.826	
F	10.26		8.73		7.45		21.67	
D.F.	11, 775		13, 773		14, 772		6, 780	
α	< 0.00005		< 0.00005		< 0.00005		< 0.00005	
F for the Group	9.064		5.579		3.279		-	
D.F.	3, 775		5, 773		6, 772		-	
Significance (* = 5%, ** = 1%)	**		**		**		-	

Turning to the microscopic accessibility indicators (significant at $\alpha = 1\%$ as a group), distance to nearest bus stop and distance to nearest park are both significant and positive. Those residing in areas where bus stops are sparsely located tend to have larger fractions of auto trips. The positive coefficient of distance to the nearest park suggests that residents of exclusively residential areas tend to show auto-dominated modal split.

Unlike the cases for the other dependent variables, many of the variables representing perceptions of living quality are significant here. These variables as a group are significant at $\alpha =$ 1%. The coefficients of cycling pleasant dummy variable and enough parking dummy variable are both positive and significant at $\alpha = 5\%$. Those who think cycling is pleasant and there are enough parking spaces in their neighborhoods are more likely to have larger fractions of their trips made by auto. The coefficient of streets pleasant for walking dummy variable is, on the other hand, negative. A possible interpretation is that the perception that walking is not pleasant leads to more frequent use of the auto for possibly safety or security reasons (therefore a negative coefficient for streets pleasant for walking dummy variable). The perception that cycling is pleasant, on the other hand, may be associated with wide streets without excessive on-street parking, which is characteristics of low-density suburban neighborhoods. Good local transit service dummy variable has a negative coefficient that is significant at $\alpha = 10\%$; those who think they have good transit service tends to have smaller fractions of auto trips.

The fact that many of the perception variables turned out to be significant for this dependent variable suggests that automobile use is strongly associated with the perception, or the assessment, of the conditions in the neighborhood. As will be discussed later, this is not the case for the fraction of transit trips or the fraction of non-motorized trips.

The best model comprises: cars per person, driver's license holding, high education dummy variable, parking spaces available, distance to nearest bus stop, and distance to nearest park. All variables except high education dummy variable are highly significant, and the model explains 14.29% of the variations in this dependent variable. Auto vs. non-auto modal split is primarily a function of auto availability, parking availability and accessibility to opportunities.

Demographic and other socio-economic attributes of households and individuals do not appear to exert appreciable effects on this modal split.

Fraction of Transit Trips

Models for the fraction of transit trips are summarized in Table 6.6. Significant variables in the base model are: household size, number of persons over 16 years old, number of cars, driver's license, graduate school dummy variable, high personal income dummy variable, and years in Bay Area. Over 13% of the total variation in the dependent variable is explained by the model.

Indicators of vehicle availability, number of cars and driver's license, are strongly and negatively correlated with the fraction of transit trips (significant at $\alpha = 1\%$). The coefficients of household size and number of persons over 16 years together imply that individuals from larger households with persons over 16 years old tend to have larger fractions of transit trips, while those from larger households with younger persons tend to have smaller fractions. The presence of children in the household appears to lead to a shift in modal split toward the automobile.
Individuals with graduate education tend to have smaller fractions of transit trips, while those with higher personal incomes tend to have larger fractions. As in the case for the number of transit trips, the number of years that the household had been in the Bay Area is negatively associated with the fraction of transit trips.

The study area dummy variables for South San Francisco, Concord and Pleasant Hill have significant positive coefficients, indicating that respondents from these study areas were more inclined to use public transit. All these study areas have BART access. The coefficient for North San Francisco is positive but not significantly different from 0. As before, the coefficient for San Jose is set as 0, which, like the case for the number of transit trips, turned out to be the lowest among the five areas. This set of variables as a group is significant at $\alpha = 5\%$.

Consistent with the above finding, the coefficient estimate for BART access is significant (at $\alpha = 1\%$) and positive. None of the other macroscopic area descriptors is significant. These variables as a group are significant at $\alpha = 5\%$.

Table 6.6
Linear Regression Models of the Fraction of Transit Trips

	Base Model		Area Dummy Variables		Macro Area Descriptors		Pedestrian/ Bike Facilities	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	-1.200		-1.487		-1.420		-1.255	
Household Size	-0.222	-4.11	-0.223	-4.06	-0.226	-4.14	-0.222	-4.09
No. of Persons Over 16 Yrs. Old	0.410	4.59	0.417	4.62	0.419	4.64	0.414	4.62
No. of Cars	-0.353	-6.43	-0.335	-5.98	-0.338	-6.03	-0.356	-6.44
Driver's License	-0.936	-4.71	-0.908	-4.57	-0.914	-4.61	-0.940	-4.72
Age Divided by 10	-0.001	-0.01	0.004	0.24	0.005	0.31	-0.001	0.00
Employment Dummy Variable	0.093	0.73	0.099	0.77	0.102	0.79	0.094	0.73
Professional Dummy Variable	0.085	0.82	0.072	0.69	0.068	0.65	0.083	0.80
Graduate School Dummy Variable	-0.307	-3.18	-0.304	-3.15	-0.304	-3.15	-0.306	-3.16
High Personal Income Dummy Variable	0.227	2.26	0.205	2.02	0.206	2.03	0.232	2.31
Years in Bay Area Divided by 10	-0.065	-2.77	-0.067	-2.78	-0.069	-2.89	-0.064	-2.73
North San Francisco			0.110	0.67				
South San Francisco			0.310	2.46				
Concord			0.315	2.56				
Pleasant Hill			0.264	2.08				
BART Access					0.254	2.62		
Mixed Land Use					-0.018	-0.15		
High Density					0.007	0.06		
Sidewalk							0.029	0.25
Bike Path							0.053	0.54
Backyard								
Parking Spaces Available								
Own Home								
Distance to Nearest Bus Stop								
Distance to Nearest Rail Station								
Dist. to Nearest Grocery Store								
Dist. to Nearest Gas Station								
Dist. to Nearest Park								
No Reason to Move								
Streets Pleasant for Walking								
Cycling Pleasant								
Good Local Transit Service								
Enough Parking								
Problems of Traffic Congestion								
R^2	0.1319		0.1426		0.1418		0.1324	
Standard Error of Estimation	1.140		1.136		1.136		1.141	
F	11.66		9.06		9.71		9.73	
D.F.	10, 767		14, 763		13, 764		12, 765	
α	< 0.00005		< 0.00005		< 0.00005		< 0.00005	
F for the Group	-		2.368		2.942		0.198	
D.F.	-		4, 763		3, 764		2, 765	
Significance (* = 5%, ** = 1%)	-		*		*			

Table 6.6
(Continued)

	Housing Choice		Accessibility		Perception of Living Quality		Best Model	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	-1.012		-0.995		-1.234		-0.728	
Household Size	-0.191	-3.45	-0.225	-4.17	-0.221	-4.03		
No. of Persons Over 16 Yrs. Old	0.398	4.44	0.400	4.49	0.390	4.34	0.203	2.86
No. of Cars	-0.328	-5.78	-0.341	-6.20	-0.337	-6.03	-0.335	-6.09
Driver's License	-0.914	-4.61	-0.931	-4.70	-0.942	-4.73	-0.919	-4.68
Age Divided by 10	0.001	0.09	0.004	0.24	-0.003	-0.19		
Employment Dummy Variable	0.053	0.41	0.102	0.79	0.085	0.66		
Professional Dummy Variable	0.080	0.76	0.075	0.72	0.107	1.01	0.099	1.05
Graduate School Dummy Variable	-0.306	-3.17	-0.299	-3.11	-0.306	-3.16	-0.306	-3.20
High Personal Income Dummy Variable	0.270	2.66	0.209	2.09	0.201	1.98	0.195	1.96
Years in Bay Area Divided by 10	-0.043	-1.71	-0.071	-3.04	-0.059	-2.36	-0.039	-1.67
North San Francisco								
South San Francisco								
Concord								
Pleasant Hill								
BART Access								
Mixed Land Use								
High Density								
Sidewalk								
Bike Path								
Backyard	-0.299	-2.17					-0.489	-3.88
Parking Spaces Available	0.001	0.05						
Own Home	-0.135	-1.09						
Distance to Nearest Bus Stop			-0.209	-0.95				
Distance to Nearest Rail Station			-0.081	-2.46			-0.084	-2.70
Dist. to Nearest Grocery Store			-0.025	-0.29				
Dist. to Nearest Gas Station			0.081	0.97				
Dist. to Nearest Park			-0.097	-1.67			-0.140	-2.52
No Reason to Move					-0.009	-0.10		
Streets Pleasant for Walking					0.117	0.83		
Cycling Pleasant					-0.116	-1.18		
Good Local Transit Service					0.171	1.61		
Enough Parking					-0.086	-0.78		
Problems of Traffic Congestion					-0.136	-1.52		
R^2	0.1420		0.1468		0.1396		0.1415	
Standard Error of Estimation	1.136		1.134		1.140		1.134	
F	9.73		8.74		7.72		12.64	
D.F.	13, 764		15, 762		16, 761		10, 767	
α	< 0.00005		< 0.00005		< 0.00005		< 0.00005	
F for the Group	3.008		2.665		1.138		-	
D.F.	3, 764		5, 762		6, 761		-	
Significance (* = 5%, ** = 1%)	*		*				-	

The pedestrian/bicycle facilities indicators again exhibit statistically insignificant association with the dependent variable.

Of the housing choice indicators, backyard has a significant (at $\alpha = 5\%$) negative coefficient, suggesting auto-oriented modal split in suburbs.

Distance to nearest rail station has a significant (at $\alpha = 2\%$) negative coefficient. The coefficient of distance to nearest park is also negative and significant at 10%. These microscopic accessibility indicators together increase the R^2 from 13.19% of the base model to 14.68%, and are as a group significant at $\alpha = 5\%$. Clearly accessibility to transit stops is an important factor that is associated with the fraction of transit trips.

Unlike the case of the fraction of auto trips, the variables representing perceptions of living quality are not significant and as a group only marginally contribute to the model's goodness of fit. Although not significant at $\alpha = 10\%$, good local transit service dummy variable has a positive coefficient and problems of traffic congestion dummy variable has a negative coefficient. Their weak (not significant at a 10% level) association with the dependent variable suggests that perceptions and actual mode choice behavior are not so strongly correlated for public transit as for the automobile.

In addition to the selected seven demographic and socio-economic variables, the best model includes backyard dummy variable, distance to nearest rail station, and distance to nearest park. Backyard dummy variable can be viewed as an indicator of residential density. The best model thus suggests that neighborhood characteristics are important determinants of the fraction of public transit trips. Unlike the case for auto vs. non-auto modal split, many socio-economic attributes are significantly associated with transit vs. non-transit modal split.

Table 6.7
Linear Regression Models of the Fraction of Non-motorized Trips

	Base Model		Area Dummy Variables		Macro Area Descriptors		Pedestrian/ Bike Facilities	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	-1.480		-1.993		-1.756		-1.721	
Household Size	-0.068	-1.61	-0.048	-1.12	-0.058	-1.37	-0.066	-1.56
No. of Cars	-0.057	-1.21	-0.018	-0.38	-0.024	-0.49	-0.060	-1.25
Driver's License	-0.674	-3.56	-0.620	-3.30	-0.645	-3.42	-0.679	-3.58
Age Divided by 10	0.023	1.45	0.019	1.21	0.022	1.41	0.022	1.38
Student Dummy Variable	-0.443	-1.93	-0.485	-2.13	-0.483	-2.11	-0.449	-1.96
Professional Dummy Variable	0.066	0.77	0.057	0.66	0.046	0.53	0.058	0.67
Household Income (in $10,000)	-0.008	-0.14	-0.032	-0.52	-0.026	-0.42	-0.014	-0.22
(Household Income)$^{1/2}$	-0.058	-0.18	0.026	0.08	0.003	0.01	-0.023	-0.07
Years in Bay Area Divided by 10	-0.006	-0.28	0.007	0.29	0.001	0.05	-0.003	-0.13
North San Francisco			0.570	3.68				
South San Francisco			0.417	3.40				
Concord			0.201	1.71				
Pleasant Hill			0.280	2.29				
BART Access					0.012	0.13		
Mixed Land Use					-0.047	-0.40		
High Density					0.257	2.64		
Sidewalk							0.164	1.49
Bike Path							0.110	1.33
Backyard								
Parking Spaces Available								
Own Home								
Distance to Nearest Bus Stop								
Distance to Nearest Rail Station								
Dist. to Nearest Grocery Store								
Dist. to Nearest Gas Station								
Dist. to Nearest Park								
No Reason to Move								
Streets Pleasant for Walking								
Cycling Pleasant								
Good Local Transit Service								
Enough Parking								
Problems of Traffic Congestion								
R^2	0.0475		0.0690		0.0611		0.0515	
Standard Error of Estimation	1.113		1.104		1.108		1.113	
F	4.38		4.48		4.26		3.88	
D.F.	9, 789		13, 785		12, 786		11, 787	
α	< 0.00005		< 0.00005		< 0.00005		< 0.00005	
F for the Group	-		4.532		3.779		1.639	
D.F.	-		4, 785		3, 786		2, 787	
Significance (* = 5%, ** = 1%)	-		**		**			

Table 6.7
(Continued)

	Housing Choice		Accessibility		Perception of Living Quality		Best Model	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Intercept	-1.459		-1.189		-1.512		-1.518	
Household Size	-0.054	-1.25	-0.075	-1.80	-0.067	-1.57	-0.089	-2.38
No. of Cars	-0.037	-0.76	-0.055	-1.16	-0.050	-1.03		
Driver's License	-0.652	-3.43	-0.646	-3.43	-0.670	-3.53	-0.649	-3.51
Age Divided by 10	0.024	1.54	0.025	1.57	0.020	1.26		
Student Dummy Variable	-0.469	-2.04	-0.442	-1.94	-0.492	-2.13		
Professional Dummy Variable	0.061	0.70	0.069	0.80	0.072	0.82		
Household Income (in $10,000)	-0.011	-0.18	-0.013	-0.21	-0.017	-0.27	-0.031	-0.51
(Household Income)$^{1/2}$	-0.025	-0.08	-0.047	-0.15	-0.026	-0.08	0.032	0.10
Years in Bay Area Divided by 10	0.010	0.42	-0.011	-0.48	-0.007	-0.27		
North San Francisco								
South San Francisco								
Concord								
Pleasant Hill								
BART Access								
Mixed Land Use								
High Density							0.280	3.37
Sidewalk								
Bike Path								
Backyard	-0.081	-0.60						
Parking Spaces Available	-0.018	-1.01						
Own Home	-0.128	-1.06						
Distance to Nearest Bus Stop			-0.347	-1.69			-0.393	-2.12
Distance to Nearest Rail Station			-0.034	-1.08				
Dist. to Nearest Grocery Store			-0.083	-1.01				
Dist. to Nearest Gas Station			-0.020	-0.25				
Dist. to Nearest Park			-0.107	-1.90			-0.138	-2.57
No Reason to Move					0.041	0.45		
Streets Pleasant for Walking					0.061	0.45		
Cycling Pleasant					-0.070	-0.75		
Good Local Transit Service					0.111	1.09		
Enough Parking					-0.099	-0.95		
Problems of Traffic Congestion					-0.097	-1.12		
R^2	0.0526		0.0688		0.0523		0.0666	
Standard Error of Estimation	1.113		1.104		1.115		1.101	
F	3.63		4.14		2.88		8.07	
D.F.	12, 786		14, 784		15, 783		7, 791	
α	< 0.00005		< 0.00005		0.0002		< 0.00005	
F for the Group	1.388		3.584		0.659			
D.F.	3, 786		5, 784		6, 783			
Significance (* = 5%, ** = 1%)			**					

Fraction of Non-Motorized Trips

Like the number of non-motorized trips, the fraction of non-motorized trips is difficult to model as indicated by the small R^2's and F-statistics in Table 6.7. Number of cars has a negative coefficient but not significant (at $\alpha = 10\%$) in the base model. Nor are the two income variables included in the model. Its significant coefficients indicate that those with a driver's license and students tend to have smaller fractions of non-motorized trips. The former variables is significant at $\alpha = 1\%$, and the latter at $\alpha = 10\%$.

The study area dummy variables considerably improve the model's fit, adding more than 2% to the R^2 value. They as a group are significant at $\alpha = 1\%$. The estimated coefficient values indicate that North and South San Francisco respondents on average had the largest fractions of non-motorized trips, followed by Pleasant Hill. North and South San Francisco have coefficients that are significantly different from 0 at $\alpha = 1\%$, while the coefficients of Pleasant Hill and Concord are significant at 5% and 10%, respectively. Average respondents from the four study areas including Concord all have fractions of non-motorized trips that are greater than that of an average respondent from San Jose, which has as before a reference coefficient value of 0.

High density dummy variable has a significant positive coefficient among the macroscopic area descriptors, while BART access dummy variable and mixed land use dummy variable are not at all significant for this dependent variable. These variables as a group are significant at $\alpha = 1\%$. The pedestrian/bicycle facilities indicators, which had significant coefficients in the model for the number of non-motorized trips, have positive coefficients which are not significant at $\alpha = 10\%$ in this model.

Unlike the models for the fraction of auto trips and the fraction of transit trips, none of the housing choice indicators is significant at $\alpha = 10\%$.

The microscopic accessibility indicators offer an R^2 value of 6.88%. They are as a group significant at $\alpha = 1\%$. All distance measures have negative coefficient estimates as expected, with distance to nearest park having the most significant negative coefficient (at $\alpha = 10\%$). As before, due to multi-collinearity these variables individually have t-statistics that often indicate that they are insignificant, but collectively they significantly contribute to the model's explanatory power.

The variables for perceptions of living quality are individually not significant, nor are they significant as a group. The best model for this dependent variable indicates that individuals from larger households and those with a driver's license tend to have smaller fractions of non-motorized trips. Importantly the model offers evidence that residential density is strongly associated with the fraction of non-motorized trips. It is also shown that neighborhood characteristics as represented by the proximity to transit stops and proximity to parks and playgrounds are also significantly associated with it. Note that these variables are introduced in addition to pertinent demographic and socio-economic variables, therefore the effects their coefficients represent are not an artifact of variations in household and person attributes across the study areas.

7. ATTITUDINAL VARIATIONS AMONG THE FIVE STUDY AREA RESPONDENTS

One important hypothesis of the study concerns the roles of attitudes that urban residents have toward energy and material consumption, environment, urban transportation, and life in general. It is conceivable that these attitudes affect urban residents' travel behavior more profoundly than do their measured attributes such as income and education. While attitudes are formed over time through direct and indirect experiences, it is likely that attitudes affect urban residents' decisions in ways that reinforce the attitudes that have been formed. It is then likely that urban residents in neighborhoods of different levels of density, land use mix, transit accessibility, or "pedestrian friendliness," have different attitudes partly because their attitudes contributed to the selection of the neighborhoods they live in, and partly because the environment they live in leads to the formation of certain attitudes.

7.1. Analysis of 39 Attitudinal Questions

The analysis of this section focuses on the responses to Part B of Phase Two, the Individual Questionnaire. A total of 39 questions were asked, each presented a statement and soliced a response on a five-point strongly agree to strongly disagree scale. These questions are divided into eight groups: Private Automobile, Ridesharing, Public Transportation, Transportation, Time, Environment, Housing and Economy.

Most respondents indicated that driving provides freedom (Table 7.1). Of the 1,444 respondents who responded, 783 (54.2%) indicated "strongly agree" and 540 (37.4%) "agree" to the statement, "Driving allows me freedom." The fraction of individuals who disagreed with this statement is less than 3%. It is evident that these urban residents perceive that the door-to-door mobility offered by the automobile allows "freedom." The association between the attitudinal response and study sites is significant with South San Francisco respondents showing a strong tendency of disagreeing with the statement. Overall, however, the association is relatively weak.

Table 7.1
Attitudes toward the Private Automobile: Agreement with the Statement, "Driving Allows Me Freedom."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	1	0.4	6	2.6	18	7.9	80	35.1	123	54.0	228	100.0
S. San Francisco	5	1.7	13	4.5	22	7.6	90	31.1	159	55.0	289	100.0
Concord	1	0.3	3	1.0	19	6.5	123	42.0	147	50.2	293	100.0
Pleasant Hill	1	0.3	3	1.0	12	4.1	121	41.3	156	53.2	293	100.0
San Jose	4	1.2	3	0.9	10	2.9	126	37.0	198	58.1	341	100.0
Total	12	0.8	28	1.9	81	5.6	540	37.4	783	54.2	1,444	100.0

$\chi^2 = 38.5$ (35.6), df = 16 (12), $\alpha = 0.0013$, Minimum expected cell value = 1.89 (6.32)
( ): Columns 1 and 2 merged. The second number in each cell is the percentage to the row total

Likewise, nearly 90% of the respondents either strongly agreed or agreed with the statement, "Driving allows me to get more done" (Table 7.2). Again, overall the respondents are appreciative of the convenience offered by the automobile. As before, South San Francisco respondents disagree with the statement more often than statistically expected. But otherwise no noteworthy differences across the study areas are present. Again, the overall association between the attitudinal response and study area is relatively weak.

These perceptions of the utility of the automobile are not inconsistent with the responses to "Too many people drive alone." Nearly 80% of the respondents agreed with this statement, suggesting the thinking that what provides convenience and freedom tends to be overused (Table 7.3). North San Francisco respondents strongly agreed with this statement with a rate higher than statistically expected; South San Francisco respondents tended not to strongly disagree or disagree; Concord respondents tended to strongly disagree or disagree and not to strongly agree; while San Jose respondents neither agreed nor disagreed more often than expected.

Table 7.2
Attitudes toward the Private Automobile: Agreement with the Statement, "Driving Allows Me to Get More Done."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	1	0.4	11	4.8	23	10.0	92	40.0	103	44.8	230	100.0
S. San Francisco	4	1.4	14	4.9	24	8.4	109	38.0	136	47.4	287	100.0
Concord	4	1.4	3	1.0	19	6.5	138	46.9	130	44.2	294	100.0
Pleasant Hill	1	0.3	5	1.7	30	10.2	123	41.8	135	45.9	294	100.0
San Jose	2	0.6	8	2.3	20	5.9	130	38.0	182	53.2	342	100.0
Total	12	0.8	41	2.8	116	8.0	592	40.9	686	47.4	1,447	100.0

χ^2 = 38.5 (24.2), df = 16 (12), α = 0.0013, Minimum expected cell value = 1.89 (8.42)

( ): Columns 1 and 2 merged.

Table 7.3
Attitudes toward the Private Automobile: Agreement with the Statement, "Too Many People Drive Alone."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	2	0.9	7	3.1	43	18.8	94	41.1	83	36.2	229	100.0
S. San Francisco	1	0.4	4	1.4	44	15.2	150	51.9	90	31.1	289	100.0
Concord	4	1.4	13	4.4	50	17.1	159	54.3	67	22.9	293	100.0
Pleasant Hill	5	1.7	10	3.4	52	17.6	148	50.2	80	27.1	295	100.0
San Jose	4	1.2	5	1.5	81	23.6	159	46.4	94	27.4	343	100.0
Total	16	1.1	39	2.7	270	18.6	710	49.0	414	28.6	1,449	100.0

χ^2 = 32.2 (30.6), df = 16 (12), α = 0.0095, Minimum expected cell value = 2.53 (8.69)

( ): Columns 1 and 2 merged.

Attitudes toward traffic congestion as a consequence of the overuse of the automobile again show slight differences across the study areas. Overall 63.6% of the respondents strongly disagreed or disagreed to the statement, "Getting stuck in traffic doesn't bother me too much" (Table 7.4).

San Jose respondents strongly disagreed with the statement significantly less often, and agreed or strongly agreed with it significantly more often than statistically expected. On the other hand, North San Francisco respondents strongly disagreed with it more often than expected. Obviously respondents from more suburban San Jose are more tolerant of traffic congestion, while residents from high-density, pedestrian-oriented North San Francisco exhibit distaste toward it.

Table 7.4
Attitudes toward the Private Automobile: Agreement with the Statement, "Getting Stuck in Traffic Doesn't Bother Me Too Much."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	69	30.1	92	40.2	32	14.0	33	14.4	3	1.3	229	100.0
S. San Francisco	80	27.9	123	42.9	37	12.9	38	13.2	9	3.1	287	100.0
Concord	66	22.5	118	40.1	53	18.0	49	16.7	8	2.7	294	100.0
Pleasant Hill	72	24.5	112	38.1	45	15.3	59	20.1	6	2.0	294	100.0
San Jose	63	18.5	123	36.2	57	16.8	82	24.1	15	4.4	340	100.0
Total	350	24.2	568	39.3	224	15.5	261	18.1	41	2.8	1,444	100.0
$\chi^2 = 33.8$, df = 16, $\alpha = 0.0058$, Minimum expected cell value = 6.50												

Responses are almost symmetric to the statement, "I like someone else to do the driving," with 30.5% responding with "neither agree nor disagree" (Table 7.5). South San Francisco respondents tended to strongly agree, Concord respondents tended not to disagree, while San Jose respondents strongly disagreed and tended not to agree with the statement. The responses of the San Jose respondents are consistent with their attitudes toward traffic congestion.

Differences across the study areas are not statistically significant (at the 5% level) for the statement, "I am not comfortable riding with strangers" (Table 7.6). San Jose residents show the tendency of strongly agreeing and not disagreeing more often than statistically expected. However, overall the table is not significant and suggests that there is no statistical association between the response to this question and the study areas.

Table 7.5
Attitudes toward Ridesharing: Agreement with the Statement, "I Like Someone Else to Do the Driving."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	24	10.8	45	20.2	63	28.3	71	31.8	20	9.0	223	100.0
S. San Francisco	27	9.4	49	17.1	84	29.4	84	29.4	42	14.7	286	100.0
Concord	19	6.5	80	27.5	82	28.2	79	27.2	31	10.7	291	100.0
Pleasant Hill	19	6.6	63	22.0	91	31.8	88	30.8	25	8.7	286	100.0
San Jose	47	13.9	73	21.6	118	34.9	68	20.1	32	9.5	338	100.0
Total	136	9.6	310	21.8	438	30.8	390	27.4	150	10.5	1,424	100.0

$\chi^2 = 39.3$, df = 16, $\alpha = 0.0010$, Minimum expected cell value = 21.3

Attitudes toward public transportation tend to differ substantially across the study areas. Table 7.7 shows this for the statement, "I can read and do other things when I use public transportation." North San Francisco respondents show a strong tendency to strongly disagree or disagree, and not to strongly agree with the statement, more frequently than statistically expected. Contrary to this, Pleasant Hill respondents tend to strongly agree with the statement. This could be due to the difference in the public transit services available to the two locales. Respondents from the Pleasant Hill study site which has good BART access, probably considered BART when responding to this question, while North San Francisco respondents may have considered the bus which is the predominant public transit mode for them. Respondents from San Jose, on the other hand, exhibit a much-higher-than-expected frequency of responding with a "neither disagree nor agree." This presumably represents the fact that San Jose respondents tended not to use public transit and therefore were not able to respond definitively to this question.

Nearly half of the respondents either strongly disagreed or disagreed with the statement, "It costs more to use public transportation than it does to drive a car" (Table 7.8). Respondents from both North and South San Francisco tended to disagree with the statement, while those from

Concord and Pleasant Hill tended to agree with it much more often than statistically expected. As for the earlier statement, San Jose respondents tended to be neutral. The differences across the study sites are all highly significant with a chi-square value of 112.0 with 16 degrees of freedom. These differences, again, may be attributable to the perceptions people may have of the relative costs of BART versus bus, with BART traversing long distances at a high speed with fares that are not much different from those of the bus which tend to cover short distances with a lower speed.

Table 7.6.
Attitudes toward Ridesharing: Agreement with the Statement, "I Am Not Comfortable Riding with Strangers."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	13	5.8	51	22.9	66	29.6	60	26.9	33	14.8	223	100.0
S. San Francisco	9	3.2	50	17.5	93	32.6	94	33.0	39	13.7	285	100.0
Concord	6	2.1	53	18.5	93	32.4	99	34.5	36	12.5	287	100.0
Pleasant Hill	14	4.9	66	23.2	81	28.4	89	31.2	35	12.3	285	100.0
San Jose	13	3.9	49	14.5	96	28.5	118	35.0	61	18.1	337	100.0
Total	55	3.9	269	19.0	429	30.3	460	32.5	204	14.4	1,417	100.0

$\alpha\chi^2 = 23.9$, df = 16, $\alpha = 0.093$, Minimum expected cell value = 8.66

Table 7.7
Attitudes toward Public Transportation: Agreement with the Statement, "I Can Read and Do Other Things When I Use Public Transportation."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	19	8.1	43	18.4	31	13.3	108	46.2	33	14.1	234	100.0
S. San Francisco	7	2.4	24	8.4	52	18.1	144	50.2	60	20.9	287	100.0
Concord	5	1.7	19	6.5	47	16.0	158	53.9	64	21.8	293	100.0
Pleasant Hill	4	1.4	11	3.8	39	13.3	151	51.5	88	30.0	293	100.0
San Jose	12	3.6	28	8.3	81	24.1	149	44.4	66	19.6	336	100.0
Total	47	3.3	125	8.7	250	17.3	710	49.2	311	21.6	1,443	100.0

$\chi^2 = 92.9$, df = 16, $\alpha < 0.00005$, Minimum expected cell value = 7.62

Table 7.8
Attitudes toward Public Transportation: Agreement with the Statement, "It Costs More to Use Public Transportation Than It Does to Drive a Car."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	57	24.4	95	40.6	43	18.4	30	12.8	9	3.9	234	100.0
S. San Francisco	62	21.5	120	41.7	63	21.9	35	12.2	8	2.8	288	100.0
Concord	26	8.9	84	28.7	101	34.5	63	21.5	19	6.5	293	100.0
Pleasant Hill	28	9.7	87	30.1	95	32.9	68	23.5	11	3.8	289	100.0
San Jose	35	10.6	96	29.1	137	41.5	54	16.4	8	2.4	330	100.0
Total	208	14.5	482	33.6	439	30.6	250	17.4	55	3.8	1,434	100.0

$\chi^2 = 112.0$, df = 16, $\alpha < 0.00005$, Minimum expected cell value = 8.97

The same can be said about the response to the statement, "Public transportation is unreliable" (Table 7.9). Although not as strong as for the previous statement, South San Francisco respondents show the tendency of agreeing with the statement, with Pleasant Hill respondents disagreeing with it. San Jose respondents again tended to be neutral, and not to disagree with this statement. Overall, the fraction of respondents who either strongly disagreed or disagreed with this statement (36.6%) is greater than that of those who either agreed or strongly agreed with it (31.1%), suggesting an overall positive perception of the reliability of public transit.

The responses to the statement, "Buses and trains are pleasant to travel in," are split with 35.2% either agreeing or strongly agreeing, 34.1% neither agreeing nor disagreeing, and 30.7% either strongly disagreeing or disagreeing with it (Table 7.10). As before, respondents from San Francisco tended to be negative about public transit, while those from Pleasant Hill were positive. Unlike the cases for the previous statements on public transit, San Jose respondents do not have an over-representation of those responding with a "neither agree nor disagree" for this question.

Only a small fraction of the respondents agreed (13.2%) or strongly agreed (3.3%) with the statement, "I use public transportation when I cannot afford to drive" (Table 7.11). North

San Francisco respondents are agreeing with the statement most frequently, but the association between the response and study area is significant only at a 3% level. For many of the respondents of this survey, using public transit would be a choice over the automobile. The large percentage of those neither agreeing nor disagreeing, however, could be an indication that they felt this statement not applicable to them as they did not use public transit.

Table 7.9
Attitudes toward Public Transportation: Agreement with the Statement, "Public Transportation Is Unreliable."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	11	4.7	76	32.5	64	27.4	61	26.1	22	9.4	234	100.0
S. San Francisco	10	3.5	88	30.6	72	25.0	85	29.5	33	11.5	288	100.0
Concord	12	4.1	100	34.1	111	37.9	57	19.5	13	4.4	293	100.0
Pleasant Hill	18	6.2	123	42.1	90	30.8	51	17.5	10	3.4	292	100.0
San Jose	8	2.4	82	24.3	130	38.6	90	26.7	27	8.0	337	100.0
Total	59	4.1	469	32.5	467	32.3	344	23.8	105	7.3	1,444	100.0

$\chi^2 = 66.2$, df = 16, $\alpha < 0.00005$, Minimum expected cell value = 9.56

Table 7.10
Attitudes toward Public Transportation: Agreement with the Statement, "Buses and Trains Are Pleasant to Travel In."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	13	5.6	79	33.8	85	36.3	49	20.9	8	3.4	234	100.0
S. San Francisco	32	11.2	77	26.8	91	31.7	74	25.8	13	4.5	287	100.0
Concord	19	6.5	62	21.2	100	34.1	95	32.4	17	5.8	293	100.0
Pleasant Hill	17	5.9	48	16.6	107	36.9	106	36.6	12	4.1	290	100.0
San Jose	18	5.3	77	22.9	109	32.3	117	34.7	16	4.8	337	100.0
Total	99	6.9	343	23.8	492	34.1	441	30.6	66	4.6	1,441	100.0

$\chi^2 = 46.6$, df = 16, $\alpha = 0.0001$, Minimum expected cell value = 10.72

Table 7.11
Attitudes toward Public Transportation: Agreement with the Statement, "I Use Public Transportation When I Cannot Afford to Drive."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	28	12.2	47	20.5	102	44.5	36	15.7	16	7.0	229	100.0
S. San Francisco	36	12.8	68	24.1	130	46.1	38	13.5	10	3.6	282	100.0
Concord	39	13.5	74	25.6	126	43.6	40	13.8	10	3.5	289	100.0
Pleasant Hill	39	13.8	89	31.5	114	40.3	36	12.7	5	1.8	283	100.0
San Jose	55	16.5	81	24.3	156	46.7	37	11.1	5	1.5	334	100.0
Total	197	13.9	359	25.3	628	44.3	187	13.2	46	3.3	1,417	100.0

$\chi^2 = 28.1$, df = 16, $\alpha = 0.031$, Minimum expected cell value = 7.43

Table 7.12
Attitudes toward Urban Transportation: Agreement with the Statement, "Traffic Congestion Will Take Care of Itself Because People Will Make Adjustments."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	90	39.0	110	47.6	19	8.2	8	3.5	4	1.7	231	100.0
S. San Francisco	80	27.4	147	50.3	39	13.4	15	5.1	11	3.8	292	100.0
Concord	77	26.1	153	51.9	38	12.9	22	7.5	5	1.7	295	100.0
Pleasant Hill	107	37.2	139	48.3	26	9.0	15	5.2	1	0.4	288	100.0
San Jose	109	32.3	172	50.9	37	11.0	15	4.4	5	1.5	338	100.0
Total	463	32.1	721	49.9	159	11.0	75	5.2	26	1.8	1,444	100.0

$\chi^2 = 31.3$, df = 16, $\alpha = 0.0125$, Minimum expected cell value = 4.16

An overwhelming majority of the respondents strongly disagreed (32.1%) or disagreed (49.9%) to the statement, "Traffic congestion will take care of itself because people will make adjustments" (Table 7.12). Variations across the study areas are relatively small for this question, suggesting the presence of a consensus in all study areas that the problem of traffic congestion cannot be left alone.

Building more roadways, however, is not necessarily viewed as a solution to the congestion problem. In fact 11.2% of the respondents strongly disagreed and 32.6% disagreed with the statement, "We need to build more roads to help decrease congestion" (Table 7.13). These exceed the percentage of respondents agreeing (24.0%) or strongly agreeing (6.4%) with the statement. San Jose has much fewer than expected respondents who strongly disagreed with the statement, while both North and South San Francisco show more than expected numbers of respondents strongly disagreeing with it. The results are consistent with the indications so far that San Jose respondents tend to be more automobile oriented than respondents from the other study areas, especially those from San Francisco. The differences in attitudes across the study areas are significant at a 2% level.

Table 7.13
Attitudes toward Urban Transportation: Agreement with the Statement, "We Need to Build More Roads to Help Decrease Congestion."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	35	15.2	82	35.7	44	19.1	54	23.5	15	6.5	230	100.0
S. San Francisco	43	14.9	86	29.8	71	24.6	68	23.5	21	7.3	289	100.0
Concord	26	8.8	99	33.6	82	27.8	70	23.7	18	6.1	295	100.0
Pleasant Hill	38	13.2	97	33.7	72	25.0	67	23.3	14	4.9	288	100.0
San Jose	19	5.6	105	31.0	104	30.7	87	25.7	24	7.1	339	100.0
Total	161	11.2	469	32.6	373	25.9	346	24.0	92	6.4	1,441	100.0

$\chi^2 = 30.7$, $df = 16$, $\alpha = 0.0148$, Minimum expected cell value = 14.68

Strong differences exist across the study areas in attitudes towards high occupancy vehicle (HOV) lanes. Overall, 36.0% of respondents agreed and 9.3% strongly agreed with the statement, "More lanes should be set aside for carpools and buses," while 4.9% strongly disagreed and 21.9% disagreed (Table 7.14). Again, San Jose respondents gave responses that are significantly different from those of the other study areas, with much significantly larger than expected numbers strongly disagreeing or disagreeing with the statement. Both North and South San Francisco respondents strongly agreed with the statement

more often than expected. Consistent with the results so far, San Jose respondents in this table show their orientation toward single-occupant vehicles (SOVs).

Table 7.14
Attitudes toward Urban Transportation: Agreement with the Statement, "More Lanes Should Be Set Aside for Carpools and Buses."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	6	2.6	35	15.2	62	27.0	97	42.2	30	13.0	230	100.0
S. San Francisco	9	3.1	66	22.9	81	28.1	95	33.0	37	12.9	288	100.0
Concord	9	3.0	59	19.9	87	29.4	119	40.2	22	7.4	296	100.0
Pleasant Hill	18	6.2	57	19.7	84	29.1	111	38.4	19	6.6	289	100.0
San Jose	29	8.6	98	28.9	90	26.6	96	28.3	26	7.7	339	100.0
Total	71	4.9	315	21.8	404	28.0	518	35.9	134	9.3	1,442	100.0
$\chi^2 = 53.3$, df = 16, $\alpha < 0.00005$, Minimum expected cell value = 11.32												

Strong variations of similar nature can be observed across the study areas regarding the statements, "Stricter vehicle smog control laws should be introduced and enforced," and "We should provide incentives to people who use electric or other clean-fuel vehicles" (Tables 7.15 and 7.16). Both North and South San Francisco residents support the former statement more than any other study areas, with significantly fewer respondents strongly disagreeing or disagreeing with it, and significantly more strongly agreeing with it, than statistically expected. Concord respondents show the strongest tendency of disagreeing with the statement, with more respondents strongly disagreeing or disagreeing than expected. San Jose has significantly fewer respondents strongly agreeing with the statement. Similar tendencies can be found for the latter statement, although the differences across the areas are statistically not as strong.

The same conclusions can be drawn from the distribution of responses to the statement, "Environmental protection is good for California's economy" (Table 7.17). Both North and South

San Francisco respondents exhibit pro-environmental attitudes with significantly more than expected responding strongly agreeing with the statement. Concord, on the other hand, has fewer than expected respondents strongly agreeing with it. San Jose shows a similar tendency as Concord but to a much weaker extent. Pleasant Hill has a distribution that is similar to the overall distribution. The variations are statistically highly significant (at a 0.01% level).

Table 7.15
Attitudes toward Urban Transportation: Agreement with the Statement, "Stricter Vehicle Smog Control Laws Should Be Introduced and Enforced."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	8	3.5	19	8.2	42	18.1	85	36.6	78	33.6	232	100.0
S. San Francisco	6	2.1	23	7.9	60	20.6	116	39.9	86	29.6	291	100.0
Concord	30	10.1	60	20.3	79	26.7	83	28.0	44	14.9	296	100.0
Pleasant Hill	17	5.9	50	17.2	60	20.7	108	37.2	55	19.0	290	100.0
San Jose	23	6.8	55	16.2	91	26.8	120	35.3	51	15.0	340	100.0
Total	84	5.8	207	14.3	332	22.9	512	35.3	314	21.7	1,449	100.0

$\chi^2 = 95.9$, df = 16, $\alpha < 0.00005$, Minimum expected cell value = 13.45

Table 7.16
Attitudes toward Urban Transportation: Agreement with the Statement, "We Should Provide Incentives to People Who Use Electric or Other Clean-Fuel Vehicles."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	1	0.4	3	1.3	36	15.5	105	45.3	87	37.5	232	100.0
S. San Francisco	1	0.3	14	4.8	46	15.8	147	50.5	83	28.5	291	100.0
Concord	3	1.0	30	10.2	69	23.4	133	45.1	60	20.3	295	100.0
Pleasant Hill	5	1.7	14	4.8	59	20.3	138	47.6	74	25.5	290	100.0
San Jose	8	2.4	13	3.9	72	21.4	176	52.2	68	20.2	337	100.0
Total	18	1.3	74	5.1	282	19.5	699	48.4	372	25.7	1,445	100.0

$\chi^2 = 59.8$ (49.4), df = 16 (12), $\alpha < 0.00005$, Minimum expected cell value = 1.89 (14.77).
( ): Columns 1 and 2 merged.

Table 7.17
Attitudes toward Environment: Agreement with the Statement, "Environmental Protection Is Good for California's Economy."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	3	1.3	15	6.4	51	21.9	98	42.1	66	28.3	233	100.0
S. San Francisco	2	0.7	24	8.3	74	25.4	119	40.9	72	24.7	291	100.0
Concord	11	3.7	41	13.9	82	27.7	123	41.6	39	13.2	296	100.0
Pleasant Hill	10	3.5	38	13.2	86	30.0	104	36.2	49	17.1	287	100.0
San Jose	14	4.1	39	11.5	85	25.1	147	43.4	54	15.9	339	100.0
Total	40	2.8	157	10.9	378	26.1	591	40.9	280	19.4	1,446	100.0

$\chi^2 = 48.8$, df = 16, $\alpha < 0.00005$, Minimum expected cell value = 6.45

Relatively small fractions of respondents agreed (12.6%) or strongly agreed (3.3%) with the statement, "Environmentalism hurts minority and small businesses" (Table 7.18). Again, South San Francisco residents show pro-environmental attitudes with significantly (at 5%) more respondents strongly disagreeing or disagreeing with the statement. Concord exhibits an opposite orientation with significantly (at 1%) fewer respondents strongly disagreeing with it. With respect to attitudes toward environment, the results so far consistently indicate that, relatively speaking, San Francisco respondents are overall pro-environment, while Concord respondents are on average anti-environment.

Table 7.18
Attitudes toward Environment: Agreement with the Statement, "Environmentalism Hurts Minority and Small Businesses."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	38	16.3	85	36.5	87	37.3	20	8.6	3	1.3	233	100.0
S. San Francisco	47	16.4	120	41.8	87	30.3	28	9.8	5	1.7	287	100.0
Concord	18	6.2	89	30.5	129	44.2	42	14.4	14	4.8	292	100.0
Pleasant Hill	34	11.7	96	33.1	105	36.2	41	14.1	14	4.8	290	100.0
San Jose	38	11.2	110	32.5	130	38.4	50	14.8	11	3.2	339	100.0
Total	175	12.1	500	34.7	538	37.3	181	12.6	47	3.3	1,441	100.0

$\chi^2 = 47.2$, df = 16, $\alpha = 0.0001$, Minimum expected cell value = 7.60

Attitudinal variations across the study areas are extremely significant with respect to the statement, "I need to have space between me and my neighbors" (Table 7.19). Substantially more respondents from North San Francisco either strongly disagreed or disagreed with the statement (61 observed as opposed to 25.2 expected under the null hypothesis that there is no variation in attitudes across the study areas). North San Francisco respondents have fewer respondents agreeing or strongly agreeing, and significantly fewer South San Francisco respondents strongly disagreeing with the statement. Concord respondents, on the other hand, subscribe to the statement with significantly fewer than expected strongly disagreeing or disagreeing (11 observed as opposed to 32.0 expected), or neither agreeing nor disagreeing, and significantly more agreeing or strongly agreeing. San Jose offers a similar but much weaker tendency, while Pleasant Hill, as for many other statements, shows a distribution that well agrees with the overall distribution.

Table 7.19
Attitudes toward Housing: Agreement with the Statement, "I Need to Have Space Between Me and My Neighbors."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	7	3.0	54	23.3	49	21.1	86	37.1	36	15.5	232	100.0
S. San Francisco	4	1.4	34	11.7	58	19.9	150	51.6	45	15.5	291	100.0
Concord	0	0.0	11	3.7	26	8.8	170	57.8	87	29.6	294	100.0
Pleasant Hill	1	0.4	36	12.5	59	20.5	122	42.4	70	24.3	288	100.0
San Jose	0	0.0	10	3.0	41	12.1	193	56.9	95	28.0	339	100.0
Total	12	0.8	145	10.0	233	16.1	721	49.9	333	23.1	1,444	100.0

χ^2 = 155.1 (149.4), df = 16 (12), $\alpha < 0.00005$, Minimum expected cell value = 1.89 (25.22)

( ): Columns 1 and 2 merged.

Such intense variations cannot be found across the study areas with respect to "It's important for children to have a large backyard for playing" (Table 7.20). Over half of the respondents either agreed or strongly agreed with the statement. Concord respondents again show the strongest tendency to agree with it. Interestingly, North San Francisco respondents have a distribution that is not significantly different from the overall distribution, while a more than expected number of Pleasant Hill respondents strongly disagreed or disagreed with the statement. Also interestingly and unlike the cases for many other statements, a significantly fewer than expected number of San Jose respondents responded with a "neither agree nor disagree" to this statement.

Table 7.20
Attitudes toward Housing : Agreement with the Statement, "It's Important for Children to Have a Large Backyard for Playing."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	3	1.3	26	11.2	74	31.9	96	41.4	33	14.2	232	100.0
S. San Francisco	2	0.7	28	9.7	107	36.9	109	37.6	44	15.2	290	100.0
Concord	0	0.0	14	4.8	51	17.4	166	56.5	63	21.4	294	100.0
Pleasant Hill	6	2.1	35	12.1	86	29.7	111	38.3	52	17.9	290	100.0
San Jose	2	0.6	28	8.3	64	18.9	174	51.3	71	20.9	339	100.0
Total	13	0.9	131	9.1	382	26.4	656	45.4	263	18.2	1,445	100.0

χ^2 = 75.7 ( ), df = 16 (12), α < 0.00005, Minimum expected cell value = 2.09 ( )
( ): Columns 1 and 2 merged.

Table 7.21
Attitudes toward Housing: Agreement with the Statement, "Having Shops and Services within Walking Distance of My Home Would Be Important to Me."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	2	0.9	16	6.9	19	8.2	112	48.1	84	36.1	233	100.0
S. San Francisco	3	1.0	23	7.9	45	15.5	160	55.0	60	20.6	291	100.0
Concord	4	1.4	51	17.3	62	21.0	147	49.8	31	10.5	295	100.0
Pleasant Hill	3	1.0	40	13.8	60	20.6	151	51.9	37	12.7	291	100.0
San Jose	6	1.8	47	13.8	92	27.0	156	45.8	40	11.7	341	100.0
Total	18	1.2	177	12.2	278	19.2	726	50.0	252	17.4	1,451	100.0

χ^2 = 116.7 (115.6), df = 16 (12), α < 0.00005, Minimum expected cell value = 1.89 (31.3)
( ): Columns 1 and 2 merged.

Slightly over half of the respondents agreed to the statement, "Having shops and services within walking distance of my home would be important to me," and an additional 17.4% strongly agreed with it (Table 7.21). Respondents from high-density, mixed-land-use North San Francisco most strongly agreed with the statement, while respondents from Concord and San Jose tended to disagree with it. Attitudes exhibited here by the respondents appear to be well correlated with the characteristics of their residence areas and conform to their residential choice. The variations across the study areas are highly significant.

Responses to the statement, "I would only live in a multiple family unit (apartment, condo, etc.) as a last resort," are strongly correlated with the distribution of housing unit types and home ownership in the respective study areas. Respondents from North San Francisco and Pleasant Hill, where home ownership levels are the lowest and the fractions of multiple housing units are the highest among the study areas, exhibit overwhelming tendencies to disagree with the statement (Table 7.22). Respondents from Concord and San Jose, on the other hand, tend to agree with the statement. Differences across the study areas are extremely significant.

Table 7.22
Attitudes toward Housing: Agreement with the Statement, "I Would Only Live in a Multiple Family Unit (Apartment, Condo, etc.) as a Last Resort."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	43	18.5	79	34.1	48	20.7	43	18.5	19	8.2	232	100.0
S. San Francisco	12	4.1	74	25.3	56	19.2	101	34.6	49	16.8	292	100.0
Concord	16	5.4	30	10.2	40	13.6	115	39.0	94	31.9	295	100.0
Pleasant Hill	38	13.2	103	35.6	46	15.9	64	22.2	38	13.2	289	100.0
San Jose	16	4.7	55	16.1	46	13.5	125	36.7	99	29.0	341	100.0
Total	125	8.6	341	23.5	236	16.3	448	30.9	299	20.6	1,449	100.0
$\chi^2 = 203.6$, df = 16, $\alpha < 0.00005$, Minimum expected cell value = 20.0												

Nearly one half of the respondents either agreed or strongly agreed, while only a little over 20% of the respondents either strongly disagreed or disagreed with the statement, "Too much valuable agricultural land is consumed to supply housing" (Table 7.23). Unlike the preceding four statements regarding housing which yielded large and statistically significant variations across the study areas, only slight variations can be found with this statement.

Responses to the statement, "I would be willing to pay a toll to drive on an uncongested road," are rather evenly split between those agreeing and those disagreeing, with 10.4% of the respondents strongly disagreeing, 26.1% disagreeing, 21.2% neither agreeing nor disagreeing, 36.5% agreeing, and 5.7% strongly agreeing (Table 7.24). Although the fraction of respondents who strongly disagreed is larger than that of those who strongly agreed, overall there are more respondents who either agreed or strongly agreed with the statement than there are respondents who either strongly disagreed or disagreed. Of the five study areas, South San Francisco respondents are most favorably disposed to the idea of congestion tolls, while Concord residents are least favorable.

Table 7.23
Attitudes toward Housing: Agreement with the Statement, "Too Much Valuable Agricultural Land Is Consumed to Supply Housing."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	9	3.9	43	18.5	96	41.2	56	24.0	29	12.5	233	100.0
S. San Francisco	5	1.7	48	16.6	85	29.3	98	33.8	54	18.6	290	100.0
Concord	5	1.7	48	16.3	83	28.1	100	33.9	59	20.0	295	100.0
Pleasant Hill	9	3.1	49	16.9	97	33.5	96	33.1	39	13.5	290	100.0
San Jose	10	2.9	74	21.7	102	29.9	105	30.8	50	14.7	341	100.0
Total	38	2.6	262	18.1	463	32.0	455	31.4	231	15.9	1,449	100.0
$\chi^2 = 29.2$, df = 16, $\alpha = 0.0229$, Minimum expected cell value = 6.11												

A majority of the respondents agreed with the statement, "Vehicle emissions increase the need for health care" (Table 7.25). Consistent with their responses to earlier statements on the environment, San Francisco respondents agreed with this statement more strongly, with North San Francisco showing a significantly more than expected number of its respondents strongly agreeing, and South San Francisco having a significantly less than expected number of its respondents strongly disagreeing or disagreeing with the statement. A more than expected number of respondents form Concord, on the other hand, disagreed with the statement.

Table 7.24
Attitudes toward Urban Transportation: Agreement with the Statement, "I Would Be Willing to Pay a Toll to Drive on an Uncongested Road."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	17	7.3	50	21.6	57	24.6	93	40.1	15	6.5	232	100.0
S. San Francisco	27	9.3	61	21.0	51	17.5	130	44.7	22	7.6	291	100.0
Concord	34	11.5	95	32.2	68	23.1	84	28.5	14	4.8	295	100.0
Pleasant Hill	30	10.4	79	27.3	50	17.3	113	39.1	17	5.9	289	100.0
San Jose	43	12.7	92	27.1	80	23.6	109	32.2	15	4.4	339	100.0
Total	151	10.4	377	26.1	306	21.2	529	36.6	83	5.7	1,446	100.0

$\chi^2 = 37.4$, df = 16 , $\alpha = 0.0018$, Minimum expected cell value = 13.32

Table 7.25
Attitudes toward Economy: Agreement with the Statement, "Vehicle Emissions Increase the Need for Health Care."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	0	0.0	14	6.0	53	22.8	118	50.6	48	20.6	233	100.0
S. San Francisco	3	1.0	9	3.1	69	23.7	169	58.1	41	14.1	291	100.0
Concord	3	1.0	25	8.5	100	34.0	138	46.9	28	9.5	294	100.0
Pleasant Hill	5	1.7	26	9.0	78	27.1	155	53.8	24	8.3	288	100.0
San Jose	6	1.8	24	7.1	102	30.1	173	51.0	34	10.0	339	100.0
Total	17	1.2	98	6.8	402	27.8	753	52.1	175	12.1	1,445	100.0

$\chi^2 = 47.7$ (44.1), df = 16 (12), $\alpha = 0.0001$, Minimum expected cell value = 2.74
( ): Columns 1 and 2 merged.

The notion that "Using tax dollars to pay for public transportation is a good investment," also received widespread support from the respondents with 53.6% of them agreeing and another 19.4% strongly agreeing with it (Table 7.26). Again, San Francisco respondents, particularly those from North San Francisco, showed the strongest agreement, while Concord had a more than expected number of disagreeing respondents, and San Jose had a less than expected number strongly agreeing with the statement.

Table 7.26
Attitudes toward Economy: Agreement with the Statement, "Using Tax Dollars to Pay for Public Transportation is a Good Investment."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	1	0.4	7	3.0	26	11.2	125	53.7	74	31.8	233	100.0
S. San Francisco	4	1.4	11	3.8	37	12.7	172	59.1	67	23.0	291	100.0
Concord	8	2.7	40	13.6	65	22.0	137	46.4	45	15.3	295	100.0
Pleasant Hill	4	1.4	28	9.7	47	16.3	160	55.6	49	17.0	288	100.0
San Jose	10	2.9	39	11.5	65	19.1	181	53.2	45	13.2	340	100.0
Total	27	1.9	125	8.6	240	16.6	775	53.6	280	19.4	1,447	100.0

$\chi^2 = 83.4$, df = 16, $\alpha < 0.00005$, Minimum expected cell value = 4.35

Table 7.27
Attitudes toward Economy: Agreement with the Statement, "Environmental Protection Costs Too Much."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	56	24.1	86	37.1	57	24.6	25	10.8	8	3.5	232	100.0
S. San Francisco	48	16.5	117	40.2	80	27.5	38	13.1	8	2.8	291	100.0
Concord	27	9.2	87	29.5	97	32.9	68	23.1	16	5.4	295	100.0
Pleasant Hill	45	15.6	107	37.2	80	27.8	45	15.6	11	3.8	288	100.0
San Jose	41	12.1	109	32.3	106	31.4	65	19.2	17	5.0	338	100.0
Total	217	15.0	506	35.0	420	29.1	241	16.7	60	4.2	1,444	100.0

$\chi^2 = 51.6$, df = 16, $\alpha < 0.00005$, Minimum expected cell value = 9.64

The statement, "Environmental protection costs too much," was disagreed with by half of the respondents, with 15.0% strongly disagreeing (Table 7.27). Again, North San Francisco shows the most pro-environmental stance with a significantly more than expected number strongly disagreeing with the statement. Concord residents showed more reservations about environmentalism with a larger than expected number agreeing with the statement.

An almost symmetric distribution of responses can be found to the statement, "We should raise the price of gasoline to reduce congestion and air pollution" (Table 7.28). San Francisco respondents again demonstrated pro-environmental attitudes with most strongly agreeing with the statement among the five study areas. This time, however, South San Francisco respondents showed stronger levels of agreement. Concord, on the other hand, disagreed with the statement most strongly, and San Jose followed this. As often is the case, Pleasant Hill respondents showed a distribution of responses that are in good agreement with the overall distribution with all study areas pooled.

Table 7.28
Attitudes toward Economy: Agreement with the Statement,
"We Should Raise the Priceof Gasoline to Reduce Congestion and Air Pollution."

	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree		Total	
N. San Francisco	16	6.9	53	22.8	47	20.3	69	29.7	47	20.3	232	100.0
S. San Francisco	22	7.6	62	21.3	61	21.0	90	30.9	56	19.2	291	100.0
Concord	56	19.1	110	37.4	52	17.7	51	17.4	25	8.5	294	100.0
Pleasant Hill	30	10.4	91	31.5	62	21.5	70	24.2	36	12.5	289	100.0
San Jose	62	18.3	109	32.2	67	19.8	70	20.7	31	9.1	339	100.0
Total	186	12.9	425	29.4	289	20.0	350	24.2	195	13.5	1,445	100.0
$\chi^2 = 90.7$, $df = 16$, $\alpha < 0.00005$, Minimum expected cell value = 29.9												

The attitudinal responses to these statements have produced consistent pictures that portray the characteristics of the five study areas. This issue is further pursued in the next section using factor analysis.

7.2. Attitude Factors

Factor analysis was applied to the responses to the 39 attitudinal questions with the intent of reducing the dimensionality of the information contained in them. The first eight factors, which collectively explain 43.3% of the total variance in the data, are discussed here. Rotated factor loadings are summarized in Table 7.29 with absolute factor loadings of less than 0.25 suppressed for simplicity in presentation.

The first factor is primarily defined by responses to statements concerning environment: "Environmental protection costs too much" (negative loading), "Environmental protection is good for California's economy," "Environmentalism hurts minority and small businesses" (negative loading), "People and jobs are more important than the environment" (negative loading), and "Stricter vehicle smog control laws should be introduced and enforced." Other statements include: ""We need to build more roads to help decrease congestion" (negative loading), "We should provide incentives to people who use electric or other clean-fuel vehicles," "We should raise the price of gasoline to reduce congestion and air pollution," "Vehicle emissions increase the need for health care," "Whoever causes environmental damage should repair the damage," and "Using tax dollars to pay for public transportation is a good investment." Clearly this factor represents the respondents environmental orientation and is named as a "pro-environment" factor. The fact that this dimension emerged as the first factor implies that environmental concerns constitute the dimension which varies most substantially across respondents.

Responses to the statements, "Buses and trains are pleasant to travel in," "I can read and do other things when I use public transportation," and "Public transportation is unreliable" (negative loading), are the primary elements that define the second factor. This factor can be thus termed as a "pro-transit" factor. Other variables that constitute this factor include responses to: "Ridesharing saves money," "It costs more to use public transportation than it does to drive a car"

Table 7.29
Rotated Factor Loadings: Attitudinal Factors

Statement for Agree/Disagree Semantic Scale	FACTOR							
	1	2	3	4	5	6	7	8
Environmental protection costs too much.	0.792							
Environmental protection is good for California's economy.	-0.744							
Environmentalism hurts minority and small businesses.	0.709							
People and jobs are more important than the environment.	0.687							
Stricter vehicle smog control laws should be introduced and enforced.	-0.549						0.307	
We should raise the price of gasoline to reduce congestion & air pollution.	-0.492						0.255	
Vehicle emissions increase the need for health care.	-0.478					0.408		
Using tax dollars to pay for public transportation is a good investment.	-0.404	0.278				0.291		
We should provide incentives to people who use electric ... vehicles.	-0.398					0.306	0.356	
Whoever causes environmental damage should repair the damage.	-0.360		0.253					
Buses and trains are pleasant to travel in.		0.634						
I can read and do other things when I use public transportation.		0.600						
Public transportation is unreliable.		-0.580						
I need to have space between me and my neighbors.			0.756					
I would only live in a multiple family unit as a last resort.			0.658					
It's important for children to have a large backyard for playing.			0.641					
High density residential development should be encouraged.			-0.513			0.332		
Driving allows me to get more done.				0.753				
Driving allows me freedom.				0.727				
I would rather drive an electric vehicle than give up driving.				0.624				

Table 7.29
(Continued)

Statement for Agree/Disagree Semantic Scale	FACTOR							
	1	2	3	4	5	6	7	8
Getting stuck in traffic doesn't bother me too much.					-0.658			
I would like to have more time for leisure.					0.584			
I feel that I am wasting time when I have to wait.		-0.267		0.260	0.564			
Having shops and services within walking distance ... would be important.						0.578		
Too much valuable agricultural land is consumed to supply housing.						0.562	-0.268	
I would be willing to pay a toll to drive on an uncongested road.							0.575	
More lanes should be set aside for carpools and buses.							0.513	
I like to spend most of my time working.					-0.265			0.717
When ... busy at work, I get more done by cutting back on personal time.								0.656
... I would be willing to give up a day's pay to get a day off work.							0.305	-0.319
I use public transportation when I cannot afford to drive.						0.404		
Ridesharing saves money.		0.460						
Traffic congestion will take care of itself because people will adjust.		-0.286			-0.334			
I am not comfortable riding with strangers.		-0.368						
We need to build more roads to help decrease congestion.	0.357						0.449	
The rideshare car or van is often late.		-0.378				0.298		
I like someone else to do the driving.		0.367						
Too many people drive alone.		0.382			0.362			
It costs more to use public transportation than ... to drive a car.		-0.417					0.255	

(negative loading), "Too many people drive alone," "The rideshare car or van is often late" (negative loading), "I am not comfortable riding with strangers" (negative loading), "I like someone else to do the driving," "Traffic congestion will take care of itself because people will make adjustments" (negative loading), and "Using tax dollars to pay for public transportation is a good investment." This factor thus reflects the orientation towards ridesharing as well as public transit.

The third factor can be named as a "suburbanite" factor. Its primary determinants are responses to: "I need to have space between me and my neighbors," "I would only live in a multiple family unit ... as a last resort," "It's important for children to have a large backyard for playing," and "High density residential development should be encouraged" (negative loading). This factor thus represents an individual's orientation toward the consumption of land for his/her living space.

The primary determinants of the fourth factor are responses to: "Driving allows me to get more done," "Driving allows me freedom," and "I would rather drive an electric or other clean-fuel vehicle than give up driving." There is one more variable with an absolute factor loading that exceeds 0.25, "I feel that I am wasting time when I have to wait." This factor thus represents one's orientation toward the apt and ubiquitous mobility provided by the automobile. This factor will be named a "automotive mobility" factor.

The fifth factor is defined principally by responses to: "Getting stuck in traffic doesn't bother me too much" (negative loading), "I would like to have more time for leisure," and "I feel I am wasting time when I have to wait." This factor may be appropriately named as a "time pressure" factor.

Responses to "Having shops and services within walking distance of my home would be important to me," and "Too much valuable agricultural land is consumed to supply housing" are the primary determinants of the sixth factor, followed by those to: "Too many people drive alone," "Traffic congestion will take care of itself because people will make adjustments" (negative loading), "High density residential development should be encouraged," and "I like to spend most of my time working" (negative loading). People with high ratings on this factor would be oriented toward a pedestrian-oriented, high-density urban environment, leading lifestyles where work is not the dominating concern. This factor will be thus named an "urban villager" factor.

The dominant variables that define the seventh factor are responses to: "I would be willing to pay a toll to drive on an uncongested road," and "More lanes should be set aside for carpools and buses," followed by "We need to build more roads to help decrease congestion," "We should provide incentives to people who use electric or other clean-fuel vehicles," "Stricter vehicle smog control laws should be introduced and enforced," "Occasionally, I would be willing to give up a day's pay to get a day off work," "Too much valuable agricultural land is consumed to supply housing" (negative loading), and "We should raise the price of gasoline to reduce congestion and air pollution." People with high values of this factor would tend to believe in transportation control measures and regulations to resolve transportation and other urban problems. They would also tend to be positive about the expansion of facilities and tend not to have reservations about urban expansion. This factor will therefore be termed an "TCM" factor.

The final factor is defined by responses to: "I like to spend most of my time working," "When things are busy at work, I get more done by cutting back on personal time," and "Occasionally, I would be willing to give up a day's pay to get a day off work" (negative loading). This factor can be unequivocally named a "workaholic" factor.

In sum, much of the information contained in the attitudinal responses to the 39 statements can be summarized into eight dimensions:

1. pro-environment,
2. pro-transit,
3. suburbanite,
4. automotive mobility,
5. time pressure,
6. urban villager,
7. TCM, and
8. workaholic.

Differences in respondents' attitudes across the five study areas are summarized using these factors in Tables 7.30 through 7.37.

Table 7.30
Descriptive Statistics by Study Area of Factor 1: Pro-Environment

	Sample Size	Mean	S.D.	Min.	Max.
North San Francisco	141	0.340	1.022	-3.536	2.770
South San Francisco	199	0.251	0.963	-2.652	2.456
Concord	195	-0.262	0.969	-2.754	2.276
Pleasant Hill	214	-0.019	0.945	-3.536	2.166
San Jose	235	-0.092	1.053	-3.500	2.368

Table 7.31
Descriptive Statistics by Study Area of Factor 2: Pro-Transit

	Sample Size	Mean	S.D.	Min.	Max.
North San Francisco	141	-0.238	1.003	-3.428	1.846
South San Francisco	199	-0.088	0.972	-2.663	3.154
Concord	195	0.204	0.991	-2.497	2.876
Pleasant Hill	214	0.238	0.902	-2.047	2.638
San Jose	235	-0.054	1.082	-4.135	2.487

Table 7.32
Descriptive Statistics by Study Area of Factor 3: Suburbanites

	Sample Size	Mean	S.D.	Min.	Max.
North San Francisco	141	-0.466	1.113	-3.441	1.794
South San Francisco	199	-0.247	0.955	-2.939	2.332
Concord	195	0.425	0.834	-2.199	2.600
Pleasant Hill	214	-0.216	1.063	-3.079	2.029
San Jose	235	0.281	0.859	-2.391	2.127

Table 7.33
Descriptive Statistics by Study Area of Factor 4: Automotive Mobility

	Sample Size	Mean	S.D.	Min.	Max.
North San Francisco	141	-0.134	1.090	-4.989	1.935
South San Francisco	199	-0.027	1.093	-3.775	1.726
Concord	195	-0.042	0.885	-3.175	2.859
Pleasant Hill	214	-0.014	0.920	-3.024	2.211
San Jose	235	0.144	0.961	-2.886	2.186

Table 7.34
Descriptive Statistics by Study Area of Factor 5: Time Pressure

	Sample Size	Mean	S.D.	Min.	Max.
North San Francisco	141	0.136	1.016	-2.619	3.053
South San Francisco	199	0.030	0.925	-2.366	2.376
Concord	195	-0.015	1.014	-2.912	3.053
Pleasant Hill	214	0.089	1.068	-2.966	2.807
San Jose	235	-0.118	0.988	-2.780	2.364

Table 7.35
Descriptive Statistics by Study Area of Factor 6: Urban Villagers

	Sample Size	Mean	S.D.	Min.	Max.
North San Francisco	141	0.186	1.077	-2.491	3.448
South San Francisco	199	0.105	0.899	-2.198	2.448
Concord	195	0.001	0.890	-2.765	2.227
Pleasant Hill	214	-0.098	1.078	-5.408	3.597
San Jose	235	-0.048	0.961	-4.262	2.737

Table 7.36
Descriptive Statistics by Study Area of Factor 7: TCM

	Sample Size	Mean	S.D.	Min.	Max.
North San Francisco	141	0.352	0.818	-1.676	2.264
South San Francisco	199	0.159	0.966	-2.502	2.969
Concord	195	-0.195	1.015	-2.941	3.238
Pleasant Hill	214	-0.129	0.942	-3.513	2.570
San Jose	235	-0.189	0.951	-3.215	2.332

Table 7.37
Descriptive Statistics by Study Area of Factor 8: Workaholics

	Sample Size	Mean	S.D.	Min.	Max.
North San Francisco	141	-0.223	1.076	-3.568	2.208
South San Francisco	199	0.058	1.026	-5.006	2.943
Concord	195	-0.005	0.931	-2.209	2.472
Pleasant Hill	214	0.038	1.014	-2.704	3.216
San Jose	235	0.108	0.909	-2.392	2.568

8. ASSOCIATION BETWEEN ATTITUDE FACTORS AND TRIP RATES BY MODE AND MODAL SPLIT

The analysis of the previous section has identified factors that are associated with trip rates by mode and modal split through an examination of a wide range of variables including the characteristics of the neighborhoods in which the respondents resided. Excluded from the pool of explanatory variables for that analysis are the attitude factors that were identified in Chapter 6. There are several reasons for this, most important of which is that attitudes are, like travel behavior itself, elements that are to be explained, but not necessarily to be used to explain behavior. In fact there are competing hypotheses regarding the relationship between attitudes and behavior: attitudes are formed through experience as a result of behavior; attitudes prompt certain types of behavior; and interactive, two-way relationships exist between attitudes and behavior. In this chapter, the analysis of the previous chapter is extended by introducing the attitude factors into the model as explanatory variables. The intent of the section is not to identify causal relationships that may exist between attitudes and behavior, but to measure the extent of association between attitudes and behavior, in this case trip rates by mode and modal split. If the attitude factors turn out to be significantly associated with these behavioral measures, then further analysis is warranted as a future effort to inspect causal relationships between the two.

Table 8.1 shows the same best model for the total number of person trips, but re-estimated for a new sub-sample of 654 respondents for whom complete attitude scores are available. Also presented in the table is a model that includes the eight attitude factors as explanatory variables in addition to those in the best model. As the F-statistic for the attitude factors indicates, the factors as a group are significant at $\alpha = 1\%$, and improve the R^2 value from the best model's 14.33% to 17.18%. Comparison of this F-statistic with those of the models presented later would, however, show that the association between the total number of person trips and the attitude factors is relatively weak. Of the eight factors, the automotive mobility factor is significant at $\alpha = 1\%$ and the pro-transit factor at $\alpha = 2\%$. Both factors are positively associated with the number of person trips. The pro-environment factor is significant at $\alpha = 10\%$, and is also positively associated with the dependent variable.

Table 8.1
Associations between Attitude Factors and the Total Number of Person Trips

	Number of Trips			
	Best Model		With Attitude Factors	
	Coef.	t	Coef.	t
Intercept	4.537		5.373	
Household Size	2.598	8.26	2.670	8.45
Persons Over 16 Yrs. Old	-3.080	-6.70	-3.024	-6.61
Driver's License	2.254	1.80	1.846	1.47
Age Divided by 10	-0.311	-3.11	-0.278	-2.77
Student Dummy Variable	2.489	1.75	2.090	1.46
Household Income (in $10,000)	-0.849	-2.16	-0.713	-1.80
$(\text{Household Income})^{1/2}$	4.983	2.50	4.207	2.09
North San Francisco	2.101	2.50	1.981	2.32
Parking Spaces Available	-0.236	-2.32	-0.209	-2.01
Factor 1: Pro-Environment			0.466	1.86
Factor 2: Pro-Transit			0.617	2.56
Factor 3: Suburbanite			-0.184	-0.73
Factor 4: Automotive Mobility			0.754	3.01
Factor 5: Time Pressure			0.371	1.48
Factor 6: Urban Villager			0.201	0.79
Factor 7: TCM			0.008	0.03
Factor 8: Workaholic			-0.140	-0.55
R^2	0.1433		0.1718	
Standard Error of Estimation	6.204		6.138	
F	11.97		7.76	
D.F.	9, 644		17, 636	
α	< 0.00005		< 0.00005	
F for the Attitude Factors	-		2.732	
D.F.	-		8, 636	
Significance (* = 5%, ** = 1%)	-		**	

Table 8.2
Associations between Attitude Factors and the Number of Transit Trips

	Number of Transit Trips			
	Best Model		With Attitude Factors	
	Coef.	t	Coef.	t
Intercept	3.051		2.736	
Persons Over 16 Yrs. Old	0.332	2.83	0.276	2.39
No. of Cars	-0.551	-5.87	-0.491	-5.26
Driver's License	-0.741	-2.10	-0.504	-1.45
Professional Dummy Variable	0.388	2.48	0.302	1.98
Graduate School Dummy Variable	-0.518	-3.31	-0.501	-3.26
High Personal Income Dummy Variable	0.438	2.60	0.462	2.78
Years in Bay Area Divided by 10	-0.160	-3.90	-0.137	-3.26
Backyard	-0.544	-2.62	-0.602	-2.92
Distance to Nearest Rail Station	-0.138	-2.70	-0.094	-1.88
Dist. to Nearest Park	-0.239	-2.51	-0.204	-2.15
Factor 1: Pro-Environment			0.042	0.61
Factor 2: Pro-Transit			0.311	4.74
Factor 3: Suburbanite			-0.101	-1.46
Factor 4:Automotive Mobility			-0.318	-4.65
Factor 5: Time Pressure			0.080	1.15
Factor 6: Urban Villager			0.076	1.08
Factor 7: TCM			-0.022	-0.32
Factor 8: Workaholic			0.043	0.62
R^2	0.1503		0.2110	
Standard Error of Estimation	1.730		1.677	
F	11.37		9.44	
D.F.	10, 643		18, 635	
α	< 0.00005		< 0.00005	
F for the Group	-		6.104	
D.F.	-		8, 635	
Significance (* = 5%, ** = 1%)	-		**	

The number of transit trips made by the respondent is as expected associated positively with the pro-transit factor and negatively with the automotive mobility factor (Table 8.2). Interestingly, with a t-statistic of 0.61, the pro-environment factor is statistically not at all significant. The model estimation results thus suggest that the attitudes one has towards the environment are not associated with his or her use of public transit.

Contrary to this, the number of non-motorized trips shows in Table 8.3 strong positive associations with the pro-environment factor and the pro-transit factor (both significant at $\alpha = 1\%$), and also with the urban villager factor (significant at $\alpha = 10\%$). The automotive mobility exhibits a strong negative association (significant at $\alpha = 1\%$). Clearly making walking and cycling trips is strongly and consistently associated with the attitudes one has toward the environment, public transit, and the door-to-door mobility provided by the automobile. The eight attitude factors together add more than 6 percentage points (200%) to the model's explanatory power to yield an R^2-value of 9.46%.

With a t-statistic value of 6.23, the automotive mobility factor is a dominant factor in the model for the fraction of auto trips (Table 8.4). The pro-environment and pro-transit factors have significant (at $\alpha = 1\%$) negative coefficients. The time pressure and urban villager factors also have significant negative coefficients (at 5% and 10%, respectively). The coefficient of the time pressure factor is negative, presumably because those who primarily use the automobile are less time pressured. The attitude factors are collectively highly significant with an F-statistic value of 12.64. These attitude factors add to the model's explanatory power and, adding to the variance explanation of 13.50% offered by the factors in the best model such as the distance to the nearest bus stop and distance to the nearest park or playground, they increase the R^2 value to 21.25%.

Like in the model for the number of transit trips the automotive mobility and pro-transit factors are significant (both at $\alpha = 1\%$) in the model for the fraction of transit trips (Table 8.5). Again, the pro-environment factor is not at all significant.

The automotive mobility factor has a large negative coefficient (significant at $\alpha = 1\%$) in the model for the fraction of non-motorized trips (Table 8.6). As in the model for the number of non-motorized trips, the pro-environment and pro-transit factors are significant, but their coefficient values and t-statistics are both much smaller relative to those of the automotive mobility factor. The urban villager factor has a significant ($\alpha = 5\%$) positive coefficient, while the time pressure factor is not significant in this model.

Table 8.3
Associations between Attitude Factors and the Number of Non-Motorized Trips

	Number of Non-Motorized Trips			
	Best Model		With Attitude Factors	
	Coef.	t	Coef.	t
Intercept	-0.259		-0.259	
North San Francisco	1.669	4.31	1.641	4.17
BART Access	0.695	2.70	0.590	2.29
Sidewalk	0.589	2.02	0.760	2.56
Factor 1: Pro-Environment			0.355	3.43
Factor 2: Pro-Transit			0.313	3.08
Factor 3: Suburbanite			-0.012	-0.12
Factor 4: Automotive Mobility			-0.391	-3.76
Factor 5: Time Pressure			0.137	1.35
Factor 6: Urban Villager			0.202	1.91
Factor 7: TCM			-0.130	-1.24
Factor 8: Workaholic			0.086	0.82
R^2	0.0340		0.0946	
Standard Error of Estimation	2.650		2.582	
F	7.62		6.10	
D.F.	3, 650		11, 642	
α	0.0001		< 0.00005	
F for the Attitude Factors	-		5.374	
D.F.	-		8, 642	
Significance (* = 5%, ** = 1%)	-		**	

Table 8.4
Associations between Attitude Factors and the Fraction of Auto Trips

	Fraction of Auto Trips			
	Best Model		With Attitude Factors	
	Coef.	t	Coef.	t
Intercept	-2.169		-1.611	
Cars per Person	0.551	3.15	0.387	2.26
Driver's License	2.275	6.13	2.005	5.54
High Education Dummy Variable	0.118	0.77	0.138	0.91
Parking Spaces Available	0.104	3.52	0.098	3.33
Distance to Nearest Bus Stop	1.137	3.31	0.765	2.28
Dist. to Nearest Park	0.259	2.61	0.224	2.31
Factor 1: Pro-Environment			-0.148	-2.05
Factor 2: Pro-Transit			-0.222	-3.25
Factor 3: Suburbanite			0.075	1.04
Factor 4: Automotive Mobility			0.445	6.23
Factor 5: Time Pressure			-0.138	-1.98
Factor 6: Urban Villager			-0.120	-1.65
Factor 7: TCM			0.027	0.38
Factor 8: Workaholic			0.120	1.67
R^2	0.1350		0.2125	
Standard Error of Estimation	1.829		1.756	
F	16.83		12.32	
D.F.	6, 647		14, 639	
α	< 0.00005		< 0.00005	
F for the Attitude Factors	-		12.64	
D.F.	-		5.642	
Significance (* = 5%, ** = 1%)	-		**	

Table 8.5
Associations between Attitude Factors and the Fraction of Transit Trips

	Fraction of Transit Trips			
	Best Model		With Attitude Factors	
	Coef.	t	Coef.	t
Intercept	-0.975		-1.161	
Persons Over 16 Yrs. Old	0.262	3.37	0.232	3.04
No. of Cars	-0.364	-5.85	-0.338	-5.46
Driver's License	-0.727	-3.10	-0.521	-2.27
Professional Dummy Variable	0.086	0.83	0.047	0.47
Graduate School Dummy Variable	-0.306	-2.95	-0.279	-2.75
High Personal Income Dummy Variable	0.228	2.04	0.246	2.24
Years in Bay Area Divided by 10	-0.040	-1.47	-0.037	-1.32
Backyard	-0.492	-3.58	-0.549	-4.02
Distance to Nearest Rail Station	-0.081	-2.38	-0.054	-1.63
Dist. to Nearest Park	-0.113	-1.79	-0.101	-1.60
Factor 1: Pro-Environment			0.004	0.08
Factor 2: Pro-Transit			0.135	3.11
Factor 3: Suburbanite			-0.016	-0.35
Factor 4: Automotive Mobility			-0.274	-6.04
Factor 5: Time Pressure			0.001	0.03
Factor 6: Urban Villager			0.046	0.98
Factor 7: TCM			-0.036	-0.80
Factor 8: Workaholic			0.047	1.04
R^2	0.1287		0.1916	
Standard Error of Estimation	1.147		1.112	
F	9.50		8.36	
D.F.	10, 643		18, 635	
α	< 0.00005		< 0.00005	
F for the Attitude Factors	-		6.173	
D.F.	-		8, 635	
Significance (* = 5%, ** = 1%)	-		**	

The six models estimated here have made it evident that the attitude factors are strongly associated with the travel demand measures used in this analysis. They contribute to the models' explanatory power in addition to the demographic, socio-economic and neighborhood characteristics variables that are in the best models developed in Chapter 7. The number of trips by travel mode is strongly associated with factors that represent individuals' attitudes toward the environment, public transit, automotive mobility, urban forms, and time. An important next step of analysis is to determine how these attitudes are formed, how they interact with travel experience, and how these attitudes affect the choice of residential and job location, housing unit, and vehicle ownership.

9. CONCLUSION

The objective of this project has been to identify the relationship between land use and travel demand, in particular, the relationship between land use density and mixture, and vehicle use. To this end, a set of five neighborhoods was selected in the San Francisco Bay Area, where mail surveys were conducted to collect information on household demographics and socio-economics, travel patterns, life styles, and attitudes towards urban transportation, housing and environment. Three-day travel diaries were used to collect the attributes of trips made by household members of over 16 years old. In addition, detailed land use data were collected through site surveys. The analyses presented in this report are based on the results of these surveys.

Limitations of the Study

One of the important features of this research study has been the use of an extensive set of variables to examine the relationship between land use and travel demand, including perceived distance to transit facilities, perceived availability of pedestrian and bicycle facilities, various attitude measures, trip diary data, and demographic, socio-economic and land use variables. The analyses have identified many important relationships among these variables. The analyses so far, however, are limited in several ways. Firstly, the household surveys were self-administered mail surveys, which in general produce lower response rates, higher item non-responses and response errors, compared to more costly face-to-face interview or telephone interview surveys. Weights can be developed and missing variables may be imputed to correct some of these problems. These remain as future tasks. Secondly, trip diary data have not been fully utilized because geo-coding of trip origins and destinations has not been performed because it requires a significant amount of resources. Consequently the analyses contained in this report are limited in their spatial content. Thirdly, the results of the site surveys have not been fully integrated with the results of the household surveys. The analyses so far, therefore, incorporate site characteristics only to some limited extent. Fourthly, causal relations among the factors pertaining to land use, travel demand and attitudes have not been identified within the project. Finally, the analyses presented in this report are based on portions of the rich information contained in the data collected in the project. It remains as a future task to more fully utilize the data set.

Results Summary

Despite these limitations, the analyses of the data set have offered a number of valuable findings. Consistent with previous findings in the literature, the results of the regression analyses of this study indicated that vehicle ownership is not associated with the number of person trips itself, but is strongly associated with the use of travel modes. Quite importantly, the results have shown that respondents from the high density study areas on average reported 1.22 trips more per three days than did their counterparts in the low density study areas. It has also been shown that mixed land use is positively associated with the number of person trips. The analyses have thus offered evidence that land use characteristics are associated with person trip generation.

The number of cars per person and driver's license holding are the dominant explanatory variables in the model developed to explain the fraction of car trips in total person trips. The analyses also show that respondents from the North San Francisco and South San Francisco study sites tend to have smaller fractions of car trips. The distance from home to the nearest bus stop was found to be positively associated with the fraction of car trips, implying that the farther one lives from a bus stop, the larger the fraction of car trips. The analyses has also shown that those who felt that the streets were pleasant for walking in their neighborhoods, tended to have smaller fractions of car trips.

Car availability — the number of cars and driver's license holding — were both negatively associated with the number of transit trips and the fraction of transit trips. BART access and a more general measure, the distance to the nearest rail station, were both found to be strongly associated with transit trip generation and transit modal split. Clearly accessibility to transit stops is an important factor associated with transit use.

With the intent of assessing the effect of land use characteristics and pedestrian and bicycle facilities on the generation of non-motorized trips, the number of non-motorized trips and the fraction of these trips were analyzed in the study. As expected, car availability was found to be negatively associated with non-motorized trip generation. The results indicate that, other things being equal, residents in the North San Francisco study site tend to make about 1.5 walking or bicycle trips more per three days than do those in the San Jose study site. It can be safely inferred that the high density in the North San Francisco area contributes to this high non-motorized trip generation rate. The results also offer support to the conjecture that high land use density positively contributes to the generation of non-motorized trips; that having sidewalks in the neighborhood contributes to the generation of non-motorized trips; and that residents in low density suburban areas tend to make fewer non-motorized trips.

The analysis of the number and fraction of non-motorized trips indicates that neighborhood characteristics, such as residential density and the presence of sidewalks, do affect the generation of non-motorized trips. Demographic and socio-economic attributes of the household or individual do not have dominating effects on the generation of walk or bicycle trips. The results suggest that urban residents' travel behavior may be modified to some extent by site planning that encourages walking or the use of bicycles.

Future Research

Together with the importance of attitudes found in Chapter 8, the study results point to the need for further analysis of the inter-relationship among attitudes, demographic and socio-economic factors, transit accessibility and pedestrian/bicycle facilities, and land use characteristics. As future effort, it is important that the microscopic measurements of site characteristics be better integrated with the results of the household surveys and causal relations among pertinent factors, including urban residents' attitudes, be rigorously analyzed. It is also important that results of this study be validated and generalized through the use of more extensive data that can be obtained by conducting similar surveys for a wider range of neighborhoods.

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